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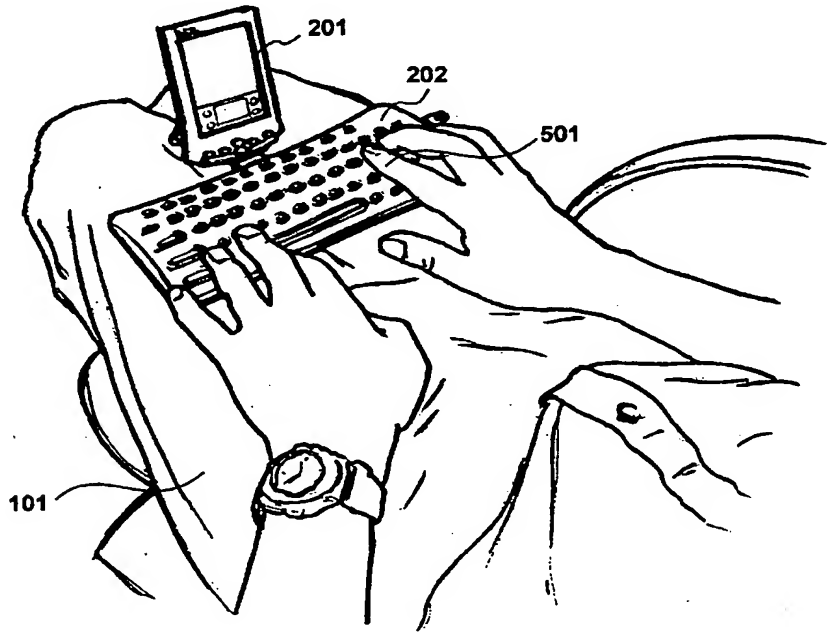

(57) Abstract: The present invention relates to a data input device suitable for inputting data to electronic processing means. The data input device is configured to produce an output in response to a mechanical interaction and may be reconfigured into two operational configurations. In a first flexible configuration the device may be bent or flexed about a first axis, and in a second rigid configuration the data input device is substantially rigid such that bending or flexing of the device about the first axis is inhibited.

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Data Input Device

Background of the Invention

1. Field of the Invention

The present invention relates to data input devices and more particularly to flexible data input devices to be used in combination with electronic processing means.

2. Description of the Related Art

Data input devices, such as keyboards or game consoles, are well known to be used in combination with electronic processor devices to enable an operator to interact and input data to the electronic processor.

In the modern working environment, it is increasingly desirable to provide portable electronic processor devices to enable operators to use such devices in off-site or out of office locations where traditional desk top devices are not practical. Examples of such devices include cellular mobile phones, and hand-held electronic processor units such as those manufactured by Palm Incorporated and Handspring.

To enable and operator to conveniently input data into such portable electronic processors it is desirable to provide a portable data input device to be used in combination with the electronic processor device. Flexible data input apparatus, such as a flexible keyboard or mouse as described in the Applicant's co-pending international patent application numbers PCT/GB01/01425 and PCT/GB01/01444. Flexible devices are desirable due

to the ease with which such devices may be folded or wrapped up for convenient storage and/or transportation.

A problem with flexible data input devices arises, however, in situations where there is no adequate support surface onto which the flexible data input device may be placed. The present invention provides a solution to such a problem enabling the use of a flexible data input device in situation where no suitable support surface is present.

Brief Summary of the Invention

According to the present invention there is provided a data input device suitable for inputting data to electronic processing means and configured to produce an output in response to a mechanical interaction, wherein said data input device has a first flexible configuration, in which said device may be bent or flexed about a first axis; and a second rigid configuration in which said data input device is substantially rigid such that bending or flexing of said device about said first axis is inhibited.

By electronic processing means, we include any portable electronic processing device that may practicably be used in an off-site or out-of-office location.

By first axis we mean any axis about which the data input device may be bent to reconfigure the device from a substantially rigid configuration to a wrapped up configuration as described herein. In preferred embodiments of the invention, bending of the data input device about a first axis means bending of the device about an axis traversing the width of the device. Therefore, in preferred embodiments, in the second rigid configuration,

bending about the first axis is inhibited thereby providing longitudinal support to the data input device along its length.

Brief Description of the Several Views of the Drawings

How the invention may be put into practice will now be described by example only in reference to the following figures in which:

Figure 1 shows an operator transporting an embodiment of the present invention in a wrapped up configuration;

Figure 2 is a perspective view of the device shown in *Figure 1*;

Figure 3 is a perspective view of the device shown in *Figure 2* in a part-unfolded configuration;

Figure 4 is a further perspective view of the device shown in *Figure 2* in a first flexible operational configuration;

Figure 5 shows an operator using the device shown in *Figure 4* on their lap in the first flexible operational configuration;

Figure 6 shows an operator using the device on their lap in a second rigid operational configuration;

Figure 7 is an exploded perspective view of a preferred embodiment of keyboard **202** illustrating the constituent layers;

Figure 8A is a plan view of the underside of the keyboard **202** in the first flexible operational configuration;

Figure 8B is a cross sectional view of keyboard **202** taken along line X - X' of *Figure 8A*;

Figure 9A is a plan view of the underside of keyboard **202** in the second rigid operational configuration;

Figure 9B is a cross sectional view taken along line X to X' of *Figure 9A*;

Figure 10 is a perspective view of an alternative embodiment of a support layer in the first flexible operational configuration;

Figure 11 shows the support layer shown in *Figure 10* bending about a first axis in the flexible configuration;

Figure 12 shows a further alternative embodiment of a support layer in the first flexible operational configuration;

Figure 13 shows a magnified view of a portion of a the support layer **1250** shown in *Figure 12*;

Figure 14A is an end view of the support layer shown in *Figure 12*;

Figure 14B is a further end view of the support layer shown in *Figure 14A* in which the support layer is bending about a first axis;

Figure 15 is a perspective view of an alternative embodiment of a support layer in a second rigid configuration;

Figure 16 is an end view of the support layer shown in *Figure 15*;

Figure 17A is a cross-sectional view taken along line X to X' of the support layer **1550** shown in *Figure 15*;

Figure 17B is a further cross sectional view showing the support layer of *Figure 14* bending about a first axis;

Figure 18 is a perspective view of an alternative embodiment of a data input device;

Figure 19 is a cross-sectional view of a portion of the data input device shown in *Figure 18*;

Figure 20 is a perspective view of the finger pump incorporated into the device shown in *Figure 18*;

Figure 21A details the electrically conductive fabric layer **701** shown in *Figure 7*;

Figure 21B details the electrically conductive fabric layer **702** shown in *Figure 7*;

Figure 22 shows a detailed view of the interface circuit;

Figures 23A, 23B, 23C and *23D* detail schematically the pressure and positional measurements that can be made by the interface circuit identified in *Figure 22*;

Figure 24 is a flow chart illustrating a mode of operation performed by the PIC16C711 processor shown in *Figure 22*;

Figure 25 is a flow chart detailing the initialisation procedure performed by the PIC16C711 processor at step **2401** shown in *Figure 24*;

Figure 26 is a further flow chart detailing the configurations of the PIC16C711 processor for the collection of Z value data as indicated in step **2402** of *Figure 24*;

Figure 27 is a flow chart detailing the configuration of the PIC16C711 processor for the collection of x and y positional co-ordinate data and z axis co-ordinate data as indicated in step **2404** of *Figure 24*;

Figure 28 is an exploded view of an alternative membrane keyboard *202*;

Figure 29 is a detailed view of the electrically conductive membrane layers **2802** and **2803** shown in *Figure 28*;

Figure 30 details the modified interface circuitry for the operation of the membrane keyboard shown in *Figures 28* and *29*;

Figure 31 is a perspective view of a data input device according to the present invention interfaced to a mobile phone;

Figure 32 shows an alternative embodiment of a data input device according to the present invention in use and connected to a portable electronic processor unit running games software.

Best Mode for Carrying Out the Invention

Figure 1

An operator **101** is shown transporting a device **102** according to the present invention in *Figure 1*. The device **102** is of suitable size and shape so as to enable convenient transportation in the pocket **103** of the operators' trousers **104**. Alternatively, the device may be conveniently transported in a brief case or a bag. The device **102** comprises an electronic processor device, which is preferably a hand-held electronic processor device that is encapsulated within a protective covering which forms the external surface of the device **102**. In this embodiment, the protective covering is formed by a flexible data input device which is wrapped around the electronic processor device during transportation and storage. The flexible data input device can be reconfigured to enable the operator to use the data input device in combination with an electronic processor to input data.

Figure 2

A perspective view of the device **102** of the present invention is shown in *Figure 2* in a wrapped-up configuration. The hand-held electronic

processor **201** is enclosed within the data input device which, in the present embodiment, is in the form of a flexible fabric keyboard **202**. In this embodiment, the hand-held electronic processor device **201** is a Palm^{RTM} Vx processor manufactured by Palm Incorporated.

In the wrapped-up configuration shown in *Figure 2*, the fabric keyboard **202** forms a protective covering around the surface of the hand-held electronic processor **201**. Hence, the fabric keyboard functions so as to provide protection against the scratching of the surface of the electronic processor and to provide a degree of cushioning against any adverse impacts to which the device **102** is exposed during transportation. In order to enable the data input device to be wrapped up around the electronic processor as shown in *Figure 2*, it is an essential feature of the fabric keyboard **202** that it is sufficiently flexible so as to enable bending of the device around the electronic processor. The device shown in *Figure 2* has two bend portions **204** and **205** which correspond to bends formed in the fabric keyboard about first and second axes respectively. In the present embodiment, the first and second axes correspond to the edges of the electronic processor device **201** and are parallel to one another.

Additionally, a zip fastener **203** is visible on the external surface of the fabric keyboard **202**. In the wrapped up configuration shown in *Figure 2*, the zip fastener **203** is in an open state and the purpose of the zip fastener will be explained further in reference to *Figures 8A*, *8B*, *9A* and *9B*.

Figure 3

The device **102** illustrated in a wrapped-up configuration in *Figure 2* is shown in a part-unfolded configuration in *Figure 3*. In the part-unfolded

configuration shown in *Figure 3*, the fabric keyboard **202** has a first lateral portion **301** which has been completely unfolded to reveal a portion of the internal surface of the keyboard **202**. Located on the internal surface of the fabric keyboard **202** are key registration devices, such as **302**, which correspond to specific alpha numerical or functional data inputs. In addition, extending along an edge of the internal surface of the first lateral portion **301** is a hook strip **303**, which forms part of a hook and loop fastener such as Velcro. The hook strip **303** releasably engages with the loop strips **304a** and **304b** that are located on the external surface of the second lateral portion **305** of keyboard **102**. The second lateral portion **305** of fabric keyboard **202**, as shown in *Figure 3*, remains partly bent about a first axis as shown at bend portion **204**. The engagement of the hook strip **303** with the loop strips **304a** and **304b** retains the keyboard **202** in the wrapped configuration shown in *Figure 2*. In an alternative embodiment, loop strips **304a** and **304b** are replaced with male press stud elements which releasably engage with corresponding female press stud elements that replace the hook strip **303** on the internal surface of portion **301** to secure the device in the wrapped up configuration.

The zip fastener **203** remains in the open position on the external surface of the fabric keyboard **202** with the zip fastener runner element **306** in a retracted position adjacent to the edge of the second lateral portion **305** of fabric keyboard **202**.

As shown in *Figure 3*, the user interface of the electronic processor device **201** is revealed by the folded back first and second lateral portions **301** and **305** of the fabric keyboard **202**. In this part unfolded configuration,

the electronic processor device **201** sits on a central portion of the fabric keyboard **202** and the user interface of the electronic processor device **201** may be accessed by an operator. The user interface of the electronic processor device **201** comprises a screen **308** and operational selection buttons, such as **309**, by which the operator may interact with the device **201** to select, view or input data.

Once the operator has finished using the user interface of the electronic processor device **201**, the flexible fabric keyboard **202** may be reconfigured to the wrapped up configuration as shown in *Figure 2* for transportation or storage. However, if the operator wishes to use the fabric keyboard **202** in combination with the electronic processor device **201** to input data then the device **102** is reconfigured into a first flexible operational configuration as shown in *Figure 4*.

Figure 4

In the first flexible operational configuration, as shown in *Figure 4*, the electronic processor **201** is displaced from the central portion of the internal surface of the fabric keyboard **202** to reveal the entire keyboard surface. The electronic processor **201** is positioned centrally along the top edge of the fabric keyboard **202** and is supported in an elevated position relative to the plane of the fabric keyboard by support leg **401**. In this configuration, an operator may use the fabric keyboard **202** to input data into the electronic processor device **201** by depressing key registration devices, such as **302**, which corresponds to a specific alpha numerical or functional data input.

The electronic processor **201** displays data inputs from the fabric keyboard on screen **308** so as to enable an operator to view the data inputs in a similar manner to that experienced when using a conventional typing system such as a desktop or lap top computer system. It is also a feature of hand held electronic processors, such as the Palm^{RTM} Vx processor, to have an on-screen keyboard display by which an operator can select individual data inputs by contacting the appropriate alpha numerical or functional icon on the screen using a stylus. The use of a keyboard, such as fabric keyboard **202**, is intended to replace this on-screen functionality by providing a more conventional keyboard and electronic processor combination which is larger and more familiar to most computer processor operators. Although not visible in *Figure 4*, an electrical connection is formed between the fabric keyboard **202** and the electronic processor **201** via an interface circuit, the function and operation of which is described in more detail in reference to *Figures 21* to *27*.

The configuration shown in *Figure 4* provides a planar keyboard surface which may conveniently be used on a supporting surface such as a table or desktop. When an operator has finished using the keyboard **202** in combination with the electronic processor **201** the keyboard may be reconfigured into the wrapped-up configuration as shown in *Figure 2*. Various approaches by which this may be achieved are described in the Applicant's co-pending International Patent Application No. PCT/GB01/01444.

Figure 5

A problem occurs, however, when an operator wishes to use the fabric keyboard **202** in combination with the electronic processor **201** in a situation where there is no suitable support surface onto which the device may be placed, such as a table or desk top, and only an uneven surface is available. Such a situation is illustrated in *Figure 5* where an operator **101** is attempting to use the fabric keyboard **202** in a first flexible operational configuration on their lap. In this situation, the operator **101** has the electronic processor device **201** supported in an elevated position between his knees and the fabric keyboard **202** resting across their lap. In this situation, when the operator **101** interacts with the fabric keyboard **202** using finger **501**, the fabric keyboard is caused to flex and bend under the pressure applied to press the keys to reflect the uneven surface onto which it has been placed. This is particularly disadvantageous as it reduces the accessibility of the key registration devices on the surface of the keyboard **202** as the keyboard contours the operators lap and hence, renders the fabric keyboard **202** difficult to use in such circumstances.

The present invention provides a solution to this problem by providing a data input device, such as fabric keyboard **202**, that has a first flexible configuration in which the keyboard may be bent or flexed about an axis so as to enable the keyboard to be folded and wrapped-up around an electronic processor for transportation and storage, and a second rigid configuration in which the keyboard is substantially rigidised so as to inhibit bending or flexing of the device about an axis and to enable the keyboard to be self-supporting to facilitate use in situations where there is no suitable support surface, such as a table or desk top.

Figure 6

Figure 6 shows the fabric keyboard **202** shown in *Figure 5* that has been reconfigured from a first flexible operational configuration into a second rigid configuration. As described before in reference to *Figure 5*, an operator **101** is illustrated in *Figure 6* using the fabric keyboard **202**, in a second rigid configuration, in combination with an electronic processor device **201** positioned on the operator's lap. In this second rigid configuration, however, the keyboard **202** has been substantially rigidised so as to prevent undesirable flexing, bending or buckling of the keyboard **202** following the application of a mechanical interaction on the keyboard surface by the operator's finger **501**. Therefore, in this configuration, an operator is provided with a rigid keyboard surface which maintains the accessibility of all the key registration devices on the surface of the keyboard and facilitates the use of the keyboard in situations where there is no adequate support surface such as, for example, when placed on an operator's lap. In other words, the disadvantages of a flexible keyboard **202** in such situations have been circumvented by the provision of a second rigidised configuration of the keyboard.

Figure 6

When an operator has finished using the device, for example as shown in *Figure 6*, the keyboard **202** may be reconfigured from the second rigid configuration to the first flexible configuration in which the keyboard may then be wrapped around the electronic processor device for storage or

transportation, as previously illustrated.

Figure 7

An exploded view of the fabric keyboard **202** illustrating the constituent layers is shown in *Figure 7*. The keyboard **202** comprises eleven constituent layers, including a first electrically conductive layer, **701** and a second electrically conductive layer **702**. Both the electrically conductive layers **701** and **702** have electrically conductive carbon coated fibres woven or knitted together so that each conductive layer is capable of conducting an electrical current in any direction across its plane.

The first electrically conductive layer **701** has conductive tracks **711** and **712** forming an electrical contact along the left and right edges of layer **701** respectively. The conductive tracks **711** and **712** are composed of fabric coated with a conductive metal, such as silver or nickel. Material of this type is readily available and is used extensively for shielding equipment from electromagnetic interference. The conductive tracks **711** and **712** are secured to the conductive layer **701** using a suitable conductive adhesive such as a pressure sensitive acrylic adhesive incorporating small copper coated conductive glass spheres.

The conductive tracks **711** and **712** are highly conductive compared to the fabric layer **701**. Accordingly, a voltage gradient may be applied across the first electrically conductive layer **701** between the right and left edges of the layer (i.e. in an X-axis direction).

Similarly, the second electrically conductive fabric layer **702** has conductive tracks **713** and **714** providing electrical contact along the top and

bottom edges of layer **702** respectively. Accordingly, a voltage may be applied across the second electrically conductive fabric layer **702** in a direction perpendicular to the voltage which is applied across the first electrically conductive fabric layer **701** (i.e. the voltage across the layer **702** is in the Y-axis direction).

Both the first and second electrically conductive fabric layers **701** and **702** are discussed further in reference to *Figure 21*.

The uppermost layer of the fabric keyboard **202** is a continuous fabric layer **703** which has printed on its upper surface graphical representations corresponding to the alpha numerical or functional data inputs to which each key on the keyboard surface corresponds. The graphical representations are preferably screen printed onto the fabric layer and during the preferred construction process the printing of the alpha numerical or functional graphical representations is performed once the fabric keyboard has been assembled. In addition, in the present embodiment, the fabric layer **703** is preferably made from a stretchable or heat formable fabric so as to enable the fabric to be manipulated to receive the protrusions of the over centre moulding layer **704**.

The over centre moulding layer **704** is, in this embodiment, a continuous silicone rubber sheet having key registration device mouldings protruding on its upper surface. The key registration device mouldings protruding from the upper surface of layer **704** are specifically moulded so as to align with the alpha numerical or functional representations printed on the uppermost layer **703**.

Located in between the first electrically conductive fabric layer **701** and the second electrically conductive fabric layer **702** are five further layers. A first masking layer **705** and a second masking layer **706** contact the innermost surfaces of the electrically conductive fabric layers **701** and **702** respectively. Both masking layers **705** and **706** are composed of a flexible tear resistant fabric with a laminate coating of polyurethane applied to one surface of the fabric. In an alternative embodiment, the masking layers **705** and **706** are sheets of polyurethane alone without any fabric constituent.

The series of circular holes **715** have been punched through the masking layers **705** and **706**. Each of these holes is located so as to align with a corresponding key registration device moulding such as **716** of layer **704**. During use of the keyboard, the masking layers prevent direct electrical contact occurring between the central conducting layer **707** (to be described later) and either of the first or second electrically conductive fabric layers **701** and **702**, except at locations which correspond to the depression of a key registration device such as **716**. Therefore, the accidental compression of a portion of the keyboard at locations between the key registration devices does not result in an output from the fabric keyboard.

Located in between the masking layers **705** and **706** are insulating mesh layers **708** and **709**, which are positioned either side of the centrally conductive layer **707**. The insulating layers **708** and **709** are composed of fabric fibres woven or knitted together with a relatively wide spacing between the fibres. This enables the first and second conductive layer to be physically separated from the central conductive layer **707** whilst enabling these layers to come into electrical contact when a mechanical pressure is applied to a

key registration device of the keyboard. The presence of these insulating layers ensures that the overall construction may be bent, flexed or wrapped around objects without causing the two conductive layers to be brought into electrical contact and thereby producing an erroneous contact identification output.

The central conductive layer **707**, located between the insulating mesh layers **708** and **709**, is specifically configured to conduct an electric current from the upper surface of the layer to the lower surface of the layer without enabling any conduction along its plane. Therefore, the centrally conductive layer **707** is only conductive in a Z-axis direction though the plane of the layer **707**.

The central conductive layer **707** is constructed by knitting a polyester yarn of twenty four decitex filament having a single conductive filament twisted therein, such that the conductive filament appears relatively randomly in the completed knitted product. In addition, the central conductive layer **707** has a conductance perpendicular to the plane of the device i.e. in the Z axis direction that increases as it is placed under pressure thereby facilitating conduction between the layers during a mechanical interaction.

Consequently, when a key registration device, such as **716** is pressed, the first electrically conductive fabric layer **701** is forced into close electrical contact with the centrally conductive layer **707** and the second electrically conductive layer **702** through holes **715** of masking layers **705** and **706** and the spaces between the fibres of mesh layers **708** and **709**. Therefore, when a voltage is applied to the first conductive layer **701**, a current passes from the first electrically conductive layer **701** through the central layer **707** and is

discharged through the second electrically conductive layer (in the Z axis direction) at the location of the key registration device **716**.

The purpose of the first electrically conductive layer **701**, the second electrically conductive layer **702**, the central conductive layer **707**, masking layers **705** and **706** and insulating mesh layers **708** and **709** is to provide a layered assembly that is capable of detecting a mechanical interaction resulting from the depression of a key registration device on layer **704**. The position of the mechanical interaction is determined using established methodology to be described later and this positional information is then correlated with a series of look-up tables to determine the identity and the function of the key that has been pressed. The process by which a mechanical interaction is detected and the position of the mechanical interaction is determined is described in more detail in reference to *Figures 21* to *27*.

Located underneath the second electrically conductive fabric layer **702** is a support layer **750**. This layer is, in this embodiment, a layer of one millimetre thick polyurethane which is semi-flexible with a Shore hardness of approximately eighty Shore A. By semi-flexible we mean that the polyurethane may be bent or flexed when in a first flexible configuration which, in this embodiment, is when the sheet is flat. However, when the sheet is placed under elastic tension by, for example, forcing the top and bottom edges together to provide the sheet with an arched profile in one axis, the sheet becomes rigid and bending or flexing along other axes is inhibited. The material is therefore considered semi-flexible as the flexibility is configuration dependent in contrast to that of the flexible fabric layers wherein the flexibility

is independent of the configuration of the layer.

A support layer with this property, in the flexible configuration, facilitates the folding and bending operations required to reconfigure the keyboard **202** into the wrapped configuration as shown in *Figure 2*.

The support layer **750** is shown in *Figure 7* as a planar layer which represents the first flexible configuration of this layer which enables the layer to be bent or folded about an axis. This layer may also be reconfigured to a provide rigidity to the fabric keyboard **202** in a second rigid configuration in which the folding or flexing of the layer about an axis is inhibited. This layer will be discussed in more detail in reference to *Figures 8A*, *8B*, *9A* and *9B*.

In an alternative embodiment, support layer **750** is made of an alternative plastics material such as polypropylene.

A final layer of the keyboard **202** that forms the external surface on the underside of the device is fabric layer **710**. This fabric layer forms the undersurface of the keyboard and the external surface of the device **102** when reconfigured to the wrapped-up configuration. To provide sufficient durability, this fabric layer is preferably manufactured from a durable and stretch resistant fabric material such as Rip Stop nylon. Fabric layer **710** also comprises the zip fastener **203** with a zip fastener element **306** shown in *Figure 7* in the retracted position with the zip fastener **203** open. The function of this zip fastener will be discussed further in reference to *Figures 8A*, *8B*, *9A* and *9B*.

The uppermost fabric layer **703** and the lower most fabric layer **710** both extend beyond the dimensions of all of the other layers so as to enable the upper and lower most fabric layers to be secured together by stitching or

by the use of an adhesive, thereby encapsulating and retaining the inner layers together in the arrangement shown in *Figure 7*.

To enable reconfiguration of the keyboard it is advantageous that all the fabric layers of the keyboard **202**, with the exception of the support layer and the lower most fabric layer **710**, have a degree of elasticity to enable stretching of the fabric layers and permit a degree of relative sheer movement of the fabric layers during reconfiguration.

The lower most fabric sheet **710** is preferably inextendible with low inherent elasticity to enable this layer to function in the conversion of the fabric keyboard from a flexible to a rigid configuration.

Figure 8

A plan view of the underneath surface of an assembled fabric keyboard in the first flexible configuration is illustrated in *Figure 8A*. As described in reference to *Figure 7*, fabric layer **710** forms the lower most layer of the assembled keyboard **202**. The lower most layer **710** comprises two portions, **801** and **802**, that are stitched together to form fabric layer **710**. A zip fastener **203** is provided between the two portions **801** and **802**. In the first flexible configuration, the zip fastener **203** is in the open position with the zip fastener element **306** in a retracted position on the left hand side of the keyboard **202**. The semi-flexible support layer **750** provides an inherent proportion of elastic rigidity to the keyboard **202** such that, in this configuration the zip fastener **203** is splayed apart to define an eliptical gap with a maximum separation indicated at **803**. This feature is further exaggerated by fabricating the portions **801** and **802** to be narrower in width

at position **804** compared to position **805**.

Figures 8A and 8B

Figure 8B is a cross-sectional view taken along line X-X' of *Figure 8A*. For clarity of illustration, only the upper fabric layer **703**, the support layer **750** and the lower most fabric layer **710** are shown in *Figure 8B*. The uppermost fabric layer **703** is formed to the shape of the key registration device protrusions of layer **704** (not shown) and the support layer **750** is in the flat planar configuration as shown in *Figure 7*. The fabric layers **701** to **702** and **704** to **709** are sandwiched in between the upper surface of the support layer **750** and the uppermost fabric layer **703**. The lower most fabric layer **710** is also shown with portions **801** and **802** separated by gap **803** formed in zip fastener **203**. The keyboard **202** is substantially flat in this embodiment with a small maximum beam thickness as indicated by arrow **806**.

Figure 9A

In situations where an operator wishes to use the fabric keyboard **202** in a rigid configuration the keyboard **202** is reconfigured to a second rigid configuration. A plan view of the underneath surface of an assembled fabric keyboard **202** in the second rigid configuration is illustrated in *Figure 9A*. The keyboard **202** has been reconfigured to this second configuration by drawing the retracted zip fastener element **306** from the left hand side of the keyboard **202** shown in *Figure 8A* to the right hand side of the keyboard as shown in *Figure 9A*, thereby closing the zip fastener **203**. As the zip fastener element **306** is drawn across the lower surface of the fabric keyboard, the stretch

resistant Rip Stop fabric of layer **710** draws in the bottom and top edges **901** and **902** of the fabric keyboard. This effect is greatest at the positions of where the gap between the portion of zip fastener **203** is greatest in the open configuration as shown at **803** in *Figure 8A*. In alternative embodiments, alternative means such as laces are used in the place of zip fastener **203**. The effect of closing the zip fastener on the cross-sectional profile of the keyboard **202** is shown in *Figure 9B*.

Figures 9B

Figure 9B is a cross-sectional view taken along line X-X' of *Figure 9A*. For clarity of illustration, only the upper fabric layer **703**, the support layer **750** and the lower most fabric layer **710** are shown in *Figure 9B*. In the second rigid configuration, zip fastener **203** is closed causing the stretch resistant lower fabric layer **710** to draw in the bottom and top edges **901** and **902** as previously described. The pressure produced by drawing in the bottom and top edges **901** and **902** causes the support layer **750** to deform into an arched configuration. The support layer **750**, in this arched configuration, is placed under elastic tension which inhibits the folding of the keyboard **202** about any axis and provides a rigid surface to enable an operator to interact with the keyboard surface without causing any bending or flexing of the keyboard under normal finger pressures.

The deformation of the support layer **750** forces the upper fabric layer **703** and fabric layers **701** to **702** and **704** to **709** (not shown) to distend upwards. It is for this reason that all the fabric layers positioned above the support layer **750** have a degree of elasticity to allow a degree of extension

and shear movement between the respective layers. The distension of the support layer **750** provides a resultant increase in the maximum beam thickness shown at **904**. This beam thickness is greater than the maximum beam thickness shown at **806** in *Figure 8B*. The second rigid configuration is therefore associated with a greater maximum beam thickness than that which occurs in the first flexible configuration.

Figure 10

An alternative embodiment of the support layer **750** of the present invention is shown in *Figure 10* in the first flexible configuration. This support layer **1050** may be substituted for the support layer **750** as shown in *Figure 7*, *8A*, *8B*, *9A* and *9B*. Support layer **1050** is a one millimetre thick sheet of polyurethane having a Shore Hardness of approximately eighty Shore A and parallel corrugations **1001** extending across the width of the support layer **1050** parallel to the direction of arrow **1002**. Therefore, support sheet is essentially the same as support sheet **750** with the addition of parallel corrugations. The purpose of the corrugations **1001** is to assist the ease with which the semi-flexible support layer **1050** may be folded about axes parallel to arrow **1002** in the first flexible operational configuration.

Figure 11

A perspective view of *Figure 11* bent about a first axis parallel to arrow **1002** of *Figure 10* is shown in *Figure 11*. Bends such as that illustrated are required to enable the device to be wrapped around the electronic processor **201** as shown by bend portions **204** and **205** of *Figure 2*. For this reason, it is

necessary that the corrugations **1001** extend in a direction parallel to the axis about which the keyboard **202** is to bend during these wrapping operations (the first axis). In *Figure 11*, the support sheet is bent about a first axis with corrugations **1001** on the outer surface of the bend. The corrugations define thick portions **1102** with thin portions **1101** interposed between the thick portions. The thin portion **1101** provide less resistance to the formation of bends and therefore, require less manual force to enable a bend to be formed. The support sheet **1050** would, however, have increased resistance to bends formed about a longitudinal axis parallel to the direction of arrow **1003** shown in *Figure 10*.

Figures 10 and *11* show the support sheet **1050** in a first flexible configuration equivalent to the configuration of support sheet **750** shown in *Figures 8A* and *8B*. The support sheet may be reconfigured to a second rigid configuration as shown for sheet **750** in *Figures 9A* and *9B*. When support sheet **1050** is displaced into an arched configuration as shown for sheet **750** in *Figure 9B*, the elastic tension formed in the support sheet **1050** provides a rigid support surface sufficient to enable an operator to use the keyboard and inhibits the flexing or bending of the keyboard about any axis. The advantage of the support sheet **1050** is the ease with which the sheet may bend about an axis parallel to the formed corrugations that reduces the manual effort required to bend the support layer **1050** (and hence the fabric keyboard **202**) in to a wrapped up configuration.

In a preferred manufacturing process the support sheet **1050** is prepared by a moulding process. In an alternative embodiment, the support sheet **1050** is prepared by an extrusion process.

In a further alternative embodiment, support layer **1050** is a sheet of polypropylene.

Figure 12

Figure 12 is perspective view of a further alternative embodiment of a support layer in a first flexible operational configuration that may substituted for support layer **750** of *Figure 7*. In this embodiment support layer **1250** is partly composed of polyester fabric fibres **1201** which extend in a weft direction and partly composed of hard nylon rods **1202** that extend in the warp direction. The hard nylon rods are preferably 0.7 millimetre diameter hard nylon monofilaments which are semi-flexible relative to the flexible fabric weft fibres. The fabric fibres **1201** are soft and flexible conventional textile fibres in the form of multi-filament yarns of polyester having a smaller diameter than the warp nylon rods **1202**.

The fabric support layer **1250** is analogous to a material used in the conventional textile industry to provide support to portions of garments in a process known as 'Whale boning'.

In an alternative embodiment, fabric fibres **1201** are mono-filament polyester yarns.

Figure 13

A portion of support layer **1250** is shown in greater detail in *Figure 13*. For the purpose of clarity of illustration only, the warp and weft fibres of support layer **1250** are shown in *Figure 13* more widely spaced than would usually be the case in practice. The warp nylon rods **1202** are shown

disposed in a planar and parallel arrangement with respect to one another and bound together by the weft fabric fibres **1201** under tension so as to provide a tight cohesive assembly of parallel warp nylon rod fibres **1202**. The support sheet **1250** is configured in a similar manner to support sheet **1050**, to facilitate a greater ease of bending about an axis parallel to arrow **1301**, whilst providing greater resistance to bending about axes parallel to arrow **1302** in the first flexible configuration. It is therefore important to align the warp rod fibres **1202** so as to be parallel with the desired axis of bending which, in this embodiment, is parallel to the arrow **1301** to enable the support layer **1250** (and hence the keyboard **202**) to be wrapped around the electronic processor with bends **204** and **205** as shown in *Figure 2*.

Figures 14A and 14B

An end view in the direction of arrow **1301** of the support layer **1250** is shown in *Figure 14A*. The warp nylon rods **1202** are shown separated by the interwoven weft fabric fibres **1201**. At the position of a bend the warp nylon rods **1202** are displaced from a common plane as shown in *Figure 14A* and the elasticity of the weft fabric fibres facilitates this displacement to form a bend as shown in *Figure 14B*. Therefore, when bending about a first axis parallel to arrow **1301** of *Figure 13*, no force is required to bend the semi-flexible nylon rods **1202** and consequently, the formation of bend about such a first axis does not require undue mechanical force. To bend about any other axis that is not parallel with arrow **1301** would require the bending or flexing of warp nylon rods **1202** and hence, would require greater manual force. It is therefore not possible to bend the support layer **1250** about a tight

radius about axes that are not parallel to the direction of the arrow **1301**.

Figures 12 to *14* show the support layer **1250** in a first flexible operational configuration in which the layer is able to bend about a first axis. The support layer may be reconfigured to a second rigid configuration by displacing the support layer **1250** to an arched configuration in which the hard nylon warp fibres **1202** are bent to form an arched profile similar to that shown for support sheet **750** in *Figure 9B*. In this second rigid configuration, elastic tension formed in the hard nylon warp fibres prevents bending or flexing of the support layer (and hence the fabric keyboard **202**) about any axis including the first axis as shown in *Figures 14A* and *14B*.

Figure 15

Figure 15 shows an alternative embodiment of a support layer in a second rigid configuration. The support layer of the present embodiment **1550** may be substituted for the layer **750** shown in *Figure 7*. In contrast to the previously described support layer embodiments **750**, **1050** and **1250**, the support layer **1550** comprises a series of elongate support portions **1502** to **1506** mounted onto a fabric sheet **1501**. The fabric sheet **1501** is a standard flexible fabric sheet comprising multi-filament polyester yarns. The support portions **1502** to **1506** are lengths of sprung steel that are attached to the fabric layer **1501** by means of a suitable adhesive. The support portions **1502** to **1506** are elongate arched strips which provide each of portions **1502** to **1506** with inherent rigidity. In this embodiment, there are five support portions arranged so as to provide support across the five horizontal rows of keys provided on the keyboard surface (see *Figure 4*). For example, support

portion **1502** provides support to the upper horizontal row of keys and support portion **1506** provides support to the bottom horizontal row of keys. Therefore, as each horizontal row of keys is provided with a corresponding support portion, these support portions provide sufficient structural support to the keyboard **202** to enable the depression of key registration devices on the keyboard surface whilst the keyboard resides on an uneven support surface without undue bending or flexing of the keyboard inhibiting effective use.

In an alternative embodiment, the support portions **1502** to **1506** are moulded strips of polyurethane having a Shore Hardness of approximately eighty Shore A.

The support portions **1502** to **1506** provide rigidity against flexing or bending along their respective lengths. However, the keyboard may be flexéd at positions between the support portions **1502** to **1506** about axis parallel to the direction of the arrow **1507**. Although a degree of flexing is facilitated between the respective support portions **1502** to **1506**, a greater resistance to bending about a first axis parallel to the direction of the arrow **1508** is provided by the support portions in the second rigid configuration, in a similar manner to the previously described support layers **750**, **1050** and **1250**. Accordingly, longitudinal rigidity is provided in the second rigid configuration across the length of support layer **1550**.

The support layer **1550** differs from the previously described embodiments of the support layer in that the support portions of support layer **1550** are fabricated in the second rigid configuration and there is no requirement to distend the support layer **1550** as a whole into the an arched configuration as is required for the previously described embodiments.

Therefore, the zip fastener arrangement **203** described in *Figures 7*, *8A*, *8B*, *9A*, and *9B* is not required for the reconfiguration of support layer **1550** to a second rigid configuration. Consequently, the layer **710** illustrated in *Figure 7* may be replaced by a continuous durable fabric sheet that forms the under surface of the keyboard **202**. It is an advantage of the support layer **1550** that the provision of separate support portions enables the support layer as a whole to remain substantially flat whilst in the second rigid configuration. This presents the operator of the keyboard with a rigid keyboard surface that remains substantially flat (i.e. it does not arch). It will be apparent from *Figure 9B* that the previously described embodiments of the support layer **750**, **1050** and **1250**, provide a rigid configuration of the keyboard with a curved upper surface.

In addition to providing rigidity to the keyboard in the second rigid configuration, the support portions **1502** to **1506** also provide tactile feedback to the operator of the keyboard by providing resistance to the mechanical interaction of the operator's finger when pressing a key until local collapsing of the arched profile occurs to enable an operator to sense that the key has been pressed with sufficient force to register a data entry. In an alternative embodiment, the support layer **1550** is substituted for the layer **704** shown in *Figure 7* so that the elongate support portions **1502** to **1506**, in addition to providing rigidity, also serve as key registration devices. In this embodiment, located along the underneath surface of each of the support portions **1502** to **1506** are downward facing protrusions which correspond to specific keys identified on the uppermost layer **703**. Therefore, the depression of a key such as a spacebar causes a limited deformation of the support portion with

the protrusion on the underside forcing the electrically conductive layers **701**, **707** and **702** into close proximity. The position of this mechanical interaction may then be determined and correlated with the data input corresponding to the depression of the spacebar key.

Figure 16

Figure 16 is an end view of the support layer **1550** in the second rigid configuration illustrating the support portions **1502** to **1506** mounted onto the fabric layer **1501**. As previously indicated, each of these portions **1502** to **1506** is fabricated with an arched cross-sectional profile so as to provide a rigidity to these portions. Accordingly, each support portion provides a maximum beam thickness as indicated at **1510**. It should be noted that, as support layer **1550** comprises a series of support portions, the maximum beam thickness **1510** is not required to be as large as that indicated for the previously described embodiments in *Figure 9B* at **904**.

Figure 17A

A cross sectional view taken along line X to X' of *Figure 15* is shown in *Figure 17A*. This cross sectional view dissects the support portion **1505** with the associated fabric layer **1501** contacting the underneath surface of support portion **1505**. As described in reference to *Figure 16*, in the second rigid configuration the support layer **1550** has a maximum beam thickness as indicated at **1510**.

Figure 17B

In order to facilitate the bending of the support layer **1550** about a first axis parallel to the arrow **1508** shown in *Figure 15* to enable the keyboard **202** to be wrapped up, it is necessary to reconfigure an area of the support portion **1505** from the second rigid configuration to a first flexible configuration as shown in *Figure 17B*. To enable the support layer **1550** to bend it is first necessary to flatten the arched profile of the support portions thereby reducing the beam thickness of the support portion as shown at **1701** in *Figure 17B*. At the position of reduced beam thickness the support layer **1550** easily bends about a first axis. Therefore, an area of the support portion **1505** shown in *Figure 17B* is reconfigured from the second rigid configuration in which bending about the first axis is inhibited to a first flexible configuration in which the bending about a first axis may occur. The reconfiguration of an area of the support portions to the first flexible configuration facilitates the wrapping of the keyboard **202** comprising the support layer 1550 around an electronic processor device **201** as illustrated in *Figure 2*.

A suitable means to reconfigure an area of the support portions **1502** to **1506** to the first flexible configuration to facilitate such bending is required. In a first embodiment, this is achieved by simple mechanical force (similar to that required to bend a sprung steel tape measure) which exceeds the force required during normal operation of the keyboard. In a second embodiment, the electronic processor may be provided with a lip protrusion along the left and right hand side edges about which the fabric keyboard **202** bends to form the wrapped configuration. Therefore, when the electronic processor **201** is placed on the keyboard **202** for reconfiguration into the wrapped up configuration the lip protrusions force the arched profiles of the support

portions from the second rigid configuration to the first flexible configuration along the edges of the electronic processor facilitating the bending of the keyboard **202** about a first axis to wrap the keyboard around the electronic processor device.

Figure 18

A further alternative embodiment of the keyboard **202** is shown in a second rigid configuration in *Figure 18*. In this embodiment the keyboard **1801** comprises a plurality of key registration devices on its upper surface in addition to a pump **1802** which serves to inflate an airtight compartment located within the keyboard **1801**. The keyboard **1801** therefore has a first flexible configuration wherein the keyboard is deflated and may be folded about an axis so as to wrap around the hand held electronic processor device **201**. In addition, the keyboard **1801** may be inflated using the finger pump **1802** to provide a second rigid configuration wherein the bending of the device about any axis is inhibited and there is a corresponding increase in the beam thickness of the keyboard **1801** as shown at **1803**.

In an alternative embodiment the finger pump **1802** is replaced by a mouth-piece valve, equivalent to the valves found on flotation aids such as arm bands and rubber rings, through which an operator directly inflates the keyboard **1801** to reconfigure the keyboard from the first flexible configuration to the second rigid configuration. Furthermore, the keyboard **1801** may be returned to the flexible configuration by releasing the air from the keyboard by squeezing the sides of the mouth-piece valve between the fingers.

Figure 19

Figure 19 shows a cross section of a portion of the keyboard **1801** shown in *Figure 18*. The keyboard includes a first outer polyurethane covered nylon layer **1901** with a similar layer, layer **1902**, at its bottom surface. In addition, there is provided a similar polyurethane covered nylon intermediate layer **1903**. The lower surface of layer **1901** is provided with a layer of adhesive **1904** that in turn contacts a first conductive layer **1905**. The first conductive layer **1905** is in contact with regions of adhesive **1906** that in turn contact an intermediate conductive layer **1907**. Below layer **1907**, there is a further layer of adhesive regions **1908** that connect layer **1907** to a second conductive layer **1909**. The second conductive layer **1909** is secured to the intermediate nylon covered polyurethane layer **1903** by a further layer of adhesive regions **1910**. In the present embodiment, the first conductive layer **1905** and the second conductive layer **1909** are identical in structure and function to the previously described first and second electrically conductive layers **701** and **702** of *Figure 7*. In addition, the intermediate conductive layer **1907** is identical to the central conductive layer **707** described in reference to *Figure 7*. Therefore, the determination of the position of a mechanical interaction is identical to that employed in the embodiment described in *Figure 7* which is detailed in *Figures 21* to *27*.

Spacer fabric **1911** is provided between the nylon layers **1902** and **1903**, and secured to said layers by means of an adhesive **1912** and **1913**. Thus, the spacer fabric **1911** is effectively contained within an airtight compartment **1915**, the size of which varies dependent upon the amount of air pressurised into this compartment by operation of the finger pump **1802**.

As shown in *Figure 19*, threads of the spacer fabric **1911** are shown in their fully extended position such that, under pressure, the degree of expansion is limited thereby providing a flat rigid keyboard structure while avoiding ballooning in any areas of the compartment **1915**. Therefore, in the second rigid configuration the compartment **1915** is pressurised with air so as to provide a rigid keyboard with an increased beam thickness. Releasing the air pressure from the compartment **1915** causes the elastic fibres **1911** to recoil and reduce the beam thickness of the compartment **1915** thereby providing a first flexible configuration of the keyboard **1801** which may be bent about a first axis to wrap the keyboard around the electronic processor **201**.

Along the edge **1916** of the keyboard the adhesive layers **1904**, **1912** and **1913** provide an airtight seal between the nylon layers **1901**, **1902** and **1903**. However, alternatively the seal may be formed by radio frequency welding of the polyurethane coating of the nylon layers.

Figure 20

Figure 20 shows a perspective view of the finger pump **1802**. The finger pump **1802** is constructed from soft polyurethane having a Shore Hardness of approximately fifty Shore A. An aperture **2001** is provided on the upper surface of the finger pump **1802** and is open to the upper surface of the keyboard **1801**, as shown in *Figure 18*. The aperture **2001** enables air to access an internal cavity of the finger pump **1802**. Placing a finger over the aperture **2001** and depressing the upper surface of the finger pump **1802** causes the expulsion of air from the internal cavity into the airtight compartment **1915** of fabric layer **1911** as shown in *Figure 19* through a

'Duck-Bill' valve **2002**. The Duck-Bill valve **2002** comprises an elongate aperture with retractable side walls that normally reside in a closed position and open following the compression of the finger pump to allow the expulsion of air form the internal cavity into the compartment **1915**.

To release air contained within the compartment **1915** of layer **1911**, pressure has to be applied to the duck bill valve **2002** in the direction of arrows **2003** as shown in *Figure 20*. This opens the valve **2002** enabling air to escape from the compartment **1915** under positive pressure provided by the elastic fibres of layer **1911**.

The following section will describe how a mechanical interaction on the surface of keyboard **202** is detected and the position of the mechanical interaction determined and correlated with a key press.

Figure 21A

The first electrically conductive fabric layer **701** shown on *Figure 7*, is shown in more detail in *Figure 21A*. Two conductive tracks **711** and **712** form the electrical contact with the conductive fibres of fabric layer **701**. A contacting portion **2111** of conductive track **711** contacts the left edge of fabric layer **701**. A conduction portion **2121** of conductive track **711** is channelled into the flexible cable **2117** and prevented from contacting the electrically conductive fabric layer **701** by insulation strip **2101** that runs along the upper edge of fabric layer **901**, and shown as a shaded area in *Figure 21A*.

Similarly, the conductive track **712** contacts the electrically conductive fabric along the right edge of fabric layer **701** via a contacting portion **2121**. A

conduction portion **2122** extends into flexible cable **2117** and is prevented from contacting the electrically conductive fabric layer **701** by insulation strip **2101** that runs along the upper edge of fabric layer **701**. This enables voltages to be applied between the contact portions **2111** and **2121** to provide a voltage gradient in the X-axis direction across the plane of fabric layer **701**.

The flexible cable forms a connection with the interface circuit which is to be described further in reference to *Figure 22*.

Figure 21B

The second electrically conductive layer **702** is shown in more detail in *Figure 21B*. Electrical connection is formed with the fabric layer **702** by the two conductive tracks **713** and **714**. Conductive track **713** forms an electrical contact with the top edge of the electrically conductive fabric layer **702** via contacting portion **2113**. A conduction portion **2123** of conductive track **713** extends over insulation strip **2102** that extends along the top edge of the fabric layer, and enters the flexible cable **2117**. Conductive track **714** forms an electrical connection with bottom edge of the fabric sheet **702** via its contacting portion **2114**. A conduction portion **2124** of conductive track **714** extends along the right edge of the fabric sheet and the top edge of the fabric sheet and enters into the flexible fabric cable **2117**. The conduction portion **2124** of conductive track **714** is electrically insulated from the fabric layer by insulating strips **2102**, which extends along the top edge, and **2103**, which extends along the right edge, of layer **702**.

Accordingly, voltages may be applied between the contact portions **2113** and **2124** of conductive tracks **713** and **714** so as to provide a voltage gradient across the electrically conductive fabric layer **702** from top to bottom in the Y-axis direction.

In this embodiment, only four connections are possible to the fabric keyboard, one connection to each of conductive tracks **711** and **712** of fabric layer **701**, and one connection to each of conductive tracks **713** and **714** of fabric layer **702**.

Figure 22

The interface circuit **2201** is located in a stand assembly that supports the electronic processor **201** (not shown) and receives the conductive tracks from layers **701** and **702**. The components of the interface circuit **2201** are shown in *Figure 22*. The interface circuit comprises a peripheral interface controller (PIC) **2202** which is connected to a serial communication output **2203** which receives power from and transmits outputs to the serial communication port of the electronic processor **201**. In addition, the PIC is connected to electrical connections **2204**, **2205**, **2206** and **2207** configured to supply and receive the necessary voltages to the conductive tracks **711**, **712**, **714** and **713** respectively. The PIC is powered by the electronic processor device which, in the case of a Palm^{RTM} Vx Processor, is within the region of 3.7 to 4 volts. Four volts will be referred to hereinafter in the description.

The PIC **2202** is a programmable controller of the type PIC16C711. The PIC **2202** operates under the control of a program which controls the parameters of the keyboard which the interface circuit **2201** is configured to

measure. Parameters under investigation will be discussed further in reference to *Figures 23* to *27*.

Under control of the PIC **2202**, the necessary output voltages can be supplied to electrical connections **2204**, **2205**, **2206** and **2207** via pins one, two, ten, eleven, twelve and thirteen of the PIC. The PIC includes an analogue to digital converter which is used to process analogue voltages received at pins seventeen and eighteen. The input pins seventeen and eighteen receive outputs from high impedance buffers **2208** and **2209** respectively. The buffers **2208** and **2209** are half of unity gain operational amplifiers of the type TL062, and provide a high impedance buffer between the sensor output voltages and the PIC **2202** input ports.

Connection to pins one and two occurs via resistors **2210** and **2211** respectively. Resistors **2210** and **2211** are selected according to the resistance of the keyboard as measured from a conducting track attached to one fabric layer **701** to a conducting track attached to the second fabric layer **702** while a typical mechanical interaction pressure, ie a key-press is applied. A value of 10Kohms is typical for resistors **2210** and **2211**. The PIC **2202** has an external crystal oscillator (not shown) running at four MHz connected across pins fifteen and sixteen. Positive four volts is supplied to pin fourteen and ground is connected to pin five. Pin four (the internal reset input) is held at positive four volts via a series resistor of one hundred ohms.

The PIC **2202** is programmed to supply and receive the necessary voltages to the conductive tracks **711**, **712**, **713** and **714** of the conductive layers **701** and **702**. By this means the interface circuit is able to determine a measure, denoted by Z, of the pressure applied to the keyboard, and if this

value is sufficiently large the interface circuit interprets this as a key-press. When a key-press is detected the interface circuit performs a measurement of the X and Y positional co-ordinates of where the pressure is being applied. The PIC is further configured to supply data to the output serial port **2203** relating to the position of key-presses detected or the absence of a key-press. The output is then correlated with a series of look-up tables in the electronic processor device which correlates the output provided with the specific key pressed and the data corresponding to that key is then registered within the electronic processor device.

An overview of the measurements made by interface circuit **2201** is illustrated by *Figures 23A*, 23*B*, 23*C* and 23*D*. The conductive layers **702** and **701** are represented schematically by potentiometers **2301** and **2302** and the resistance of the conductive path between the layers at the location of the applied force is represented by variable resistor **2303**.

Figure 23A

A first measurement is shown in *Figure 23A*. Four volts are applied to connector **2204**, while connector **2205** remains disconnected. Connector **2207** is connected to ground via a resistor **2211** of known value. Thus, current flows from connector **2204** through a first part of layer **701** indicated by a first part **2305** of potentiometer **2302**, through the conductive path indicated by variable resistor **2303** having resistance Rv, through a first part of layer **702**, indicated by a first part **2306** of potentiometer **2301** and through the known resistor **2211**. The voltage, V1 appearing at connector **2207** is measured and since this is equal to the voltage drop across resistor **2211**, V1

is directly proportional to the current flowing from connector **2204**.

Figure 23B

A second measurement is shown in *Figure 23B*. Four volts are applied to connector **2206**, while connector **2207** is disconnected. Connector **2205** is connected to ground via a resistor **2210** of known resistance. The voltage V2, dropped across resistor **2210** is measured. Voltage V2 is directly proportional to the current flowing through a second part of layer **702** indicated by a second part **2308** of potentiometer **2301**, through the conductive path indicated by variable resistor **2303** having resistance Rv, through a second part of layer **701** indicated by a second part **2309** of potentiometer **2302** and through resistor **2210**.

The sum of the resistance of first part **2306** and second part **2308** of potentiometer **2301** is approximately equal to the resistance between contacting portions **713** and **714** on layer **702**, and is therefore substantially constant during the measurements, since they occur in rapid succession. Similarly, the sum of the resistance of first part **2305** and second part **2309** of potentiometer **2302** is approximately equal to the resistance between conductive tracks **711** and **712** on layer **701**, and is also substantially constant during the measurements. As a result, the relationship **2310** exists between the resistance Rv, of the conductive path between the conductive layers **701** and **702**, and the measured voltages V1 and V2, ie the resistance Rv between the conductive layers is proportional to the sum of the reciprocal of voltage V1 and the reciprocal of voltage V2.

In general, depending upon the type of position sensor used, the resistance Rv depends upon area of the applied pressure or a function of the area and the force as illustrated by relationship **2311**. Thus, from the voltage measurements V1 and V2 a measure which is dependent on the force applied to the keyboard is determined.

Figure 23C

A third measurement is shown in *Figure 23C*. Four volts is applied to connector **2205** while connector **2204** is grounded, and so a potential gradient is produced across layer **701** represented by potentiometer **2302**. A voltage measurement is made at connector **2207**. Since the interface circuit makes use of the high impedance buffer **2208**, the voltage appearing on layer **702** at the position of the applied force is determined. This voltage, V3 is directly proportional to the distance of the centre of the applied force from contacting portion **2111** of conductive track **711** and indicates its X-axis position.

Figure 23D

A fourth measurement is shown in *Figure 23D*. Four volts are applied to connector **2207** and connector **2206** is grounded. A voltage measurement is made of voltage V4 appearing at connector **2205**. Voltage V4 is directly proportional to the distance of the centre of the applied force from contacting portion **2114** of conductive track **714** and indicates its Y-axis position. Therefore, voltage V3 and V4 provide information as to the two-dimensional position of the applied force on the sensor, i.e. voltages V3 and V4 represent

X and Y values for the centre of the position of the applied force, representing a key-press.

Figure 24

The program running within the peripheral interface circuit of *Figure 22* is outlined in the flow chart of *Figure 24*. At step **2401** the hardware is initialised and this process is detailed later with reference to *Figure 25*. At step **2402** the circuit **2201** measures values of voltages V1 and V2 and calculates a Z value of the interaction. The details of step **2402** are described later with reference to *Figure 26*. At step **2403** a question is asked as to whether the Z data is greater than a predetermined value. If the answer to this question is no then the program returns to step **2402**. Thus the circuit measures Z values until a Z value greater than a predetermined value is detected. If the answer to the question at step **2403** is yes then the circuit measures voltages V1, V2, V3 and V4 and calculates a Z value at step **2404**. Step **2404** is described later in more detail with reference to *Figure 27*. At step **2405** a question is asked as to whether the calculated Z value is still above the predetermined value. If the answer to the question is yes, a further question is asked at step **2406** as to whether enough samples have been obtained. Typically, between three and ten sets of samples are taken, with lower numbers of sets of samples being taken when a fast response time is required. If the answer to the question at step **2406** is no then the program returns to step **2404** and a further set of measurements are made. When the answer to the question at step **2406** is yes, or when the answer to the question at step **2405** is no, then the program calculates smoothed values of

the samples of the voltages V3 and V4, and of the values of Z which have been collected. Thus, the program measures a predetermined number of voltages before finding the smoothed values or, if the Z value drops below a predetermined value, the smoothed values are calculated immediately. By using a number of samples the effect of mains power electromagnetic interference or other such environmental noise may be minimised.

A simple calculation to find a smoothed value for say the X value, is to find the median of the maximum and minimum values of the stored values V3, ie a 'smoothed' value for X is found by adding the maximum stored value of V3 to the minimum stored value of V3 and dividing the result by two.

To further improve accuracy, values of X, Y, and Z that differ by a large amount from their immediately preceding and immediately subsequent values are excluded from the calculations of the smoothed value. In addition, known methods of eliminating mains electricity supply interference may be applied to the signals received from the sensor.

At step **2408** the median values for V3 and V4 representing X and Y positional co-ordinates and the averaged values of the Z data are output at the serial communication output **2203**. The program then returns to step **2402** and looks for an indication of further mechanical interaction.

Figure 25

Step **2401** of *Figure 24* is shown in further detail in *Figure 25*. Within the initialisation step **2401**, at step **2501** the interrupts are cleared and then at step **2502** pins seventeen and eighteen are set up as analogue to digital converter inputs. The micro ports of a PIC16C711 may be configured as low

impedance outputs or high impedance inputs. When in high impedance input mode, pins seventeen and eighteen can be programmed to connect via an internal multiplexer, to the analogue to digital converter. At step **2503** the ports which are to be used as inputs or outputs are configured in their initial state. At step **2504** all system variables are cleared and all interrupts are disabled.

Figure 26

Step **2402** of *Figure 24* is shown in further detail in *Figure 26*. Within step **2402**, at step **2601**, the ports corresponding to pins two and ten are reconfigured as output ports and at step **2602** pin two is set to zero while pin ten is set to positive four volts. Thus connector **2207** is grounded via resistor **2211** and four volts are applied to connector **2204**. At step **2603** a time delay (typically of two hundred microseconds in a sensor measuring ninety millimetres by two hundred and forty millimetres with an conductive layer resistance of 3.5Kohms) is provided to allow voltages to settle before the voltage at pin seventeen is measured and stored at step **2604**. Thus voltage V1 present at connector **2207** is measured and stored.

At step **2605** pins two and ten are reconfigured as high impedance inputs while pins one and twelve are reconfigured as low impedance outputs. At step **2606** the voltages on pins one and twelve are set to zero and positive four volts respectively. Thus, connector **2205** is grounded via resistor **2210** while four volts are supplied to connector **2206**. A suitable time delay, equivalent to that at step **2603**, is provided at step **2607** before the voltage at pin eighteen is measured and stored at step **2608**. Thus, the voltage present

on connector **2205** is measured and stored as voltage V2. At step **2609** a Z value is calculated from stored voltages V1 and V2, and then stored. The pins one and twelve are reconfigured back to their initial state of high impedance inputs at step **2610**.

Figure 27

Step **2404** of *Figure 24* is shown in further detail in *Figure 27*. Within step **2404**, at step **2701** a Z value is collected in the same manner as at step **2402**. At step **2702** pins one and two are reconfigured as high impedance inputs and pins ten and eleven as low impedance outputs. At step **2703** pin ten is set to zero volts and pin eleven is set to positive four volts. Thus, four volts are supplied to connector **2205** while connector **2204** is grounded. A delay is then provided at step **2704**, (of typically two hundred microseconds for a device measuring ninety millimetres by two hundred and forty millimetres) to allow voltages in the sensor to settle before the voltage on pin seventeen is measured at step **2705**. Therefore, a voltage V3 present on connector **2207** is measured which provides an indication of the X position of the applied force.

Pins ten and eleven are then reconfigured as high impedance inputs and pins twelve and thirteen are reconfigured as low impedance outputs at step **2706**. The voltage on pin twelve is then set to zero while the voltage on pin thirteen is set to four volts at step **2707**. Thus, four volts are supplied to connector **2207** while connector **2206** is grounded. A time delay is provided at step **2708**, similar to that at step **2704**, before the voltage appearing at pin eighteen is measured at step **2709**. Thus, a voltage V4 present on connector

2205 is measured which provides an indication of the Y position of the applied force. Pins twelve and thirteen are then reconfigured back to their initial state of high impedance inputs.

Therefore, by the method described with reference to *Figures 24* to *27* the interface circuit is able to make voltage measurements V3 and V4 which provide an indication of the position of the force applied to a fabric sensor, and measure voltages V1 and V2 which are proportional to currents passing through the sensor and provide information as to a second characteristic of the applied force. The second characteristic may be the pressure with which the force is applied, or a combination of the size of the force and the area. Furthermore, the circuit combines the voltages V1 and V2 to determine a Z value representative of the second characteristic.

The circuit **2201** provides output data representative of X and Y position of the applied force and the Z value. However, in an alternative embodiment the interface circuit provides output data corresponding to the measured voltages V1, V2, V3 and V4.

Figure 28

An alternative embodiment to the fabric keyboard **202**, as previously described in reference to *Figure 7*, is shown in *Figure 28*. In this embodiment, the keyboard **2850** is a membrane keyboard and is shown in an exploded perspective view in *Figure 28* to illustrate the constituent layers. The four layers shown in *Figure 28* are intended to replace layers **701** to **709** of *Figure 7*. Therefore layers **2801**, **2802**, **2803** and **2804** shown in *Figure 28* would reside above a support layer such as **750** (or any alternative embodiment of

the support layer described herein). The functionality of the lower fabric layer **710** would also be retained for the reconfiguration of the support layer **750** to the second rigid configuration as shown in *Figures 9A* and *9B*.

The uppermost layer is a silicone rubber moulded layer **2801**, identical to layer **704** previously described in reference to *Figure 7*. This layer is laminated on the upper surface with a durable fabric layer such as layer **703** (described in reference to *Figure 7*), onto which graphical icons corresponding to the individual keys are printed. In an alternative embodiment, the uppermost layer is laminated with a durable flexible plastic film, such as the polyester or polyvinyl chloride film, onto which the graphics corresponding to each key are printed.

The membrane keyboard **2801** comprises a first electrically conductive membrane film **2802** and a second electrically conductive membrane film **2803**. In addition, a spacing membrane layer **2804** is positioned in between the first electrically conductive membrane layer **2802** and the second electrically conductive membrane layer **2803**.

The first electrically conductive membrane layer **2802** is a film of Mylar^{RTM} (polyethylene terephthalate). Onto the underside of the film **2802** electrodes (formed from silver-loaded ink), such as **2810**, are printed forming the electrical conductivity portions of the first electrically conductive membrane. The electrodes are connected to an interface circuit which supplies voltages to the electrodes, such as electrode **2810**, via conductive tracks, such as **2811**. Each electrode is specifically aligned so as to correspond with a key registration device on the layer **2801**. For example, the electrode **2810** corresponds to the centre of the 'CAPS LOCK' key **2840**.

The second electrically conductive membrane layer **2803** is also composed of Mylar^{RTM} membrane having silver-loaded ink electrodes such as **2820** printed onto the upper surface which forms the electrical conductivity of the second electrically conductive membrane layer. Each of the electrodes printed onto the upper surface of layer **2803** is aligned with a corresponding electrode on layer **2802** and a corresponding key registration device on layer **2801**. For example, electrode **2820** on layer **2803** is specifically aligned with electrode **2810** on layer **2802** and the 'CAPS LOCK' key **2840** on layer **2801**.

A separator layer **2804** is a non-conductive membrane sheet of Mylar^{RTM} with holes, such as **2830**, located to coincide with the electrodes printed on to the surfaces of layers **2802** and **2803**. For example, the hole **2830** is specifically aligned with the electrode **2810** on layer **2802** and the electrode **2820** on layer **2803**.

The separator layer **2804** prevents an electrical contact occurring between the electrodes of layers **2802** and **2803** unless a mechanical interaction has occurred by pressing a key on layer **2801**. For example, the 'CAPS LOCK' key **2840**, when pressed, causes the compression of the electrode **2810** towards the electrode **2820** through the hole **2830** in the separator layer **2804**.

Accordingly, if a voltage is supplied to the electrode **2810** via the conductive track **2811**, a press of the 'CAPS LOCK' key will form an electrical contact between the electrode **2810** of layer **2802** and the electrode **2820** of layer **2803**. Therefore, a voltage output is detectable in the conductive track **2821** on layer **2803**. As the depression of the 'CAPS LOCK' key is the only key that would produce a voltage output in conductive track **2821** when a

voltage has been applied to the conductive track **2811**, then, by detecting this voltage output, the interface circuit is able to correlate the output with the corresponding electrical connections formed. This data is either correlated with look-up tables in the interface circuit to assign the correlating 'CAPS LOCK' function output with the key press or the look-up table correlation is performed in the electronic processor following an output indicating the connections formed and the output detected.

In an alternative embodiment, the membrane layers **2802**, **2803** and **2804** are made of an alternative plastics material such as polyester or polyvinyl chloride. In further alternative embodiments, layer **2803** may be made from any insulating plastic material or from a suitable fabric.

Figure 29

The electrically conductive membrane layer **2802** is shown in more detail in *Figure 29*. The layer **2802** has a conductive electrode, such as **2810**, for each key of the keyboard and the elongate space bar, in this embodiment, has six corresponding electrodes as indicated at **2920**. Voltages are applied to the electrodes via conductive tracks **2811** and **2901** to **2913** which are generally arranged to define fourteen columns respectively. The conductive tracks **2811** and **2901** to **2913** extend to form a connection with the interface circuit (not shown). In this embodiment, the interface circuit can form a connection independently with each conductive track as will be described later in reference to *Figure 30*.

The second electrically conductive membrane layer **2803** is also shown in *Figure 29*. Each conductive electrode printed on the surface of

membrane layer **2803**, such as **2820**, is connected by one of five conductive tracks **2821** and **2930** to **2934**. In contrast to the first electrically conductive layer **2802**, the conductive tracks of the second membrane layer **2803** effectively connects the electrodes to define a series of five rows that extend near perpendicularly to the columns defined by the conductive tracks on layer **2802**. Accordingly, each key, when pressed, will only produce an output in a specific row following the application of a voltage to a specific column defined on layer **2802**. For example, if a voltage is supplied to conductive track **2903** which extends to form connections to the six electrodes corresponding to the space bar key as indicated at **2920**, and the space bar key is depressed, a voltage output will be detectable in conductive track **2930** of layer **2803**. The depression of the space bar key is the only key that will produce an output in conductive track **2930** when a voltage is supplied to the conductive track **2903**.

There are many alternative configurations that the electrodes and conductive tracks may take to essentially achieve the same function to that shown in *Figure 29*. In one such example of an alternative embodiment, the conductive rows and columns are effectively printed onto the same membrane layer such that, at a given position corresponding to a key registration device, the printed electrodes of a specific row and column terminate so as to provide an open circuit with electrodes adjacent to each other in the area of a key. In this embodiment, attached to the underside of each key registration device is a 'pill' of conductive material such as carbon which, when the key is depressed, contacts and bridges the gap between the respective column and row terminal to form a closed circuit. In a similar

manner to that described in reference to *Figures 28* and 29, the detection of an output voltage in a particular row in response to a voltage supplied to a particular column will be indicative of a specific key press.

Figure 30

In order to enable the detection of a key press within an area of the keyboard described in *Figures 28* and *29*, the interface circuit is arranged as shown in *Figure 30*. The interface circuit **3001** includes a detection processor **3002**, a pressure/location detection circuit **3003**, a switching circuit **3004**, a multiplex switch **3005** having electrical connection inputs elements **3006**, an input socket **3007** and an output socket **3008** provided to allow connection to the electronic processor device.

Each of the five conductive tracks that define five rows on membrane layer **2803** has an individual connection formed thereto and each of the fourteen conductive tracks that define columns of membrane layer **2802** has a connection formed thereto. Consequently there are nineteen connections formed between the interface circuit and the keyboard. The wires corresponding to each connection are fed individually to the input elements **3006** of multiplex switching circuit **3005**.

If a key is pressed on the keyboard, the interface circuit **3001** provides an output identifying the location of a mechanical interaction. Voltages are applied to the keyboard through the pressure/location detection circuit **3003** which is essentially the same as the circuit shown in *Figure 22*. The circuit shown in *Figure 22* forms four connections which, in the interface circuit of the present embodiment, are connected to multiplex switch **3005**. In this

embodiment, only two connections of the circuit shown in *Figure 22* are utilised. For example, voltages are applied to the conductive tracks of layer **2802** via connection **2204** and connection **2207** is connected to the conductive tracks of layer **2803** to detect any output voltages. The precise arrangement of the connections formed at any given time is determined by the multiplex switch, under the control of the detection processor. In a first mode of operation, the multiplex switch conducts a sequential scan of each row following the application of a voltage to each conductive column on layer **2802**.

If an output is detected via connector **2207** in response to a key press, the pressure location detection circuit produces an output which is sent via the switching circuit **3004** to the detection processor **3002** where the output is correlated with the precise connection formed and positional information corresponding to the connections formed and the output received are sent to the electronic processor via the switching circuit **3004** and the output socket **3008**. In the present embodiment, the electronic process correlates this data with look-up tables to determine the corresponding alpha numerical or function input to which the key pressed relates.

In an alternative embodiment, to reduce the number of operations required to determine which key has been pressed and hence increase the speed with which a key press is detected, the multiplex switch **3005**, in an initial state under the control of the detection processor **3002**, connects the pressure/location detection circuit **3003** to all five conductive tracks on layer **2803** and a second connection to all fourteen conductive tracks on layer **2802**. A total of two connections to the pressure location detection circuit

3002 are made. If, on viewing these terminals, an open circuit is present, no mechanical interaction has occurred on the alpha-numeric keyboard. Alternatively, if a closed circuit is identified, this indicates the presence of a mechanical interaction and an output to this effect is supplied to switching circuit 3004 which in turn conveys this information to the detection processor **3002** and to output socket **3008**.

On detection of a mechanical interaction, the multiplex switch **3004** under the control of detection processor **3002**, maintains the connection of the pressure/location detection circuit **3003** to layer **2803**, and a single connection is made from the pressure/location detection circuit to the leftmost seven of the conductive tracks **2811** and **2901** to **2906** of layer **2802**. Again the pressure/location detection circuit **3003** detects the presence of a closed or open circuit; a closed circuit indicating one or more key presses in the leftmost half of the alpha-numeric keyboard. An output indicative of an open or closed circuit is supplied to the switching circuit **3004** which in turn conveys this information to the detection processor **3002** and to output socket **3008**.

The multiplex switching circuit is then commanded by the detection processor to disconnect the connection to the seven leftmost conductive tracks of layer **2802** and make connections from the pressure/location detection circuit **3003** to the remaining seven conductive tracks **2907** to **2913** respectively. Again an open or closed circuit is detected and the information relayed to the detection circuit **3002**. A closed circuit at this stage indicates one or more key presses in the rightmost half of the QWERTY keyboard outline.

The connections to the pressure/location detection circuit **3003** are maintained by the detection processor while the pressure location detection circuit provides an output indicative of a mechanical interaction. When a mechanical interaction is no longer indicated, the detection processor returns the multiplex switch back into the initial state.

Alternatively, if one or more key presses are detected relating to either the seven leftmost conductive tracks **2811**, **2901** to **2906**, then the detection processor **3002** performs a binary search to identify the conducting row and column intersection at which a mechanical interaction is present. The circuit does this by a process of elimination. For example, if a key press is not detected in the columns relating to conductive tracks **2907** to **2913** then no further search is necessary in respect of these columns. But, if a key press is detected in the seven leftmost conducting columns relating to conductive tracks **2811** and **2901** to **2906**, the multiplex switch **3005** under the control of detection processor **3002** makes connections from pressure/location detection circuit **3003** to the first four conductive tracks **2811** and **2901** to **2903** of layer **2802** and a further connection to the five conductive tracks on layer **2803**. Pressure/location detection circuit **3003** detects the presence of an open or closed circuit and provides an indicative output to detection processor **3002**. The multiplex switch **3005**, then makes a connection from pressure/location detection circuit **3003** to the next three attachment portions **2904** to **2906** while maintaining the connections to the five conductive tracks of layer **2803**. The pressure/location detection circuit **3003** detects the presence of an open or closed circuit and provides an indicative output to detection processor **3002**.

Thus, the control circuit identifies if just one or both of the two groups of four columns is subject to a key press. If just one of the two groups is identified as relating to a key press, then this group only is interrogated and the other group is eliminated from further search. But if both groups are identified as relating to a key press, then both groups will need to be interrogated further.

The process of binary search is continued in this manner until the identity of the individual columns relating to the key press or presses is established. A similar process is then followed to establish which of the rows contains the key press or presses. This is done by making connection of the location detection device to all fourteen conductive tracks of layer **2802** and a second connection to a varying number of the conductive tracks of layer **2803**. Having established both the row and the column, the detection processor **3002** then provides an output indicating the location(s) to output socket **3008** via the switching circuit **3004**. The detection processor then resets the multiplex switching circuit to its initial state in readiness for the next mechanical interaction to be detected.

Figure 31

The keyboard **202** can be used with any portable equipment where data entry is required or is considered desirable. A further example is shown in *Figure 31*, in which a flexible keyboard **3101** is shown in a second rigid configuration and is attached to a mobile cellular telephone **3102** via a suitable interface **3103**. Typically, communications interfaces of mobile cellular telephones are responsive to AT commands as is well known in the

art. Particular implementation of an interface device **3103** will, however, require modification in order to facilitate connection to a particular mobile phone variety and information may be required from a mobile telephone company in order to fully secure an appropriate link without invalidating warranty's.

Increasingly, mobile telephones similar to telephone **3102** are being used for the transmission of text messages, that may be achieved using second generation GSM standard via the SMS procedure. Text communication is further enhanced by WAP technologies and applications for third generation mobile telephones. Thus, a keyboard of this type becomes particularly attractive when the telephone is being used for email or web browsing applications. Therefore, a relatively small telephone can be given functionality substantially similar to that provided by more sophisticated models, such as the Nokia Communicator 9000.

Figure 32

An alternative embodiment of a data input device according to the present invention is shown in use by an operator in *Figure 32*. In this situation, the operator **3201** is a child interacting with a data input device **3202** which, in this embodiment, is a games console connected to a portable electronic processor **3203** operating games software. The games console **3202** is shown in *Figure 32* in a second rigid configuration with the operator **3201** supporting the games console **3202** between their knees. Furthermore, the operator **3201** can interact with the games console **3202** by providing mechanical interactions to the game console's surface which is translated

into game control data which is transmitted via the interface circuit to the electronic processor **3203**. The particular implementation of the interface circuit will require appropriate modification to facilitate connection to a particular variety of portable electronic processor used. In the present embodiment, the electronic processor is a Handspring Visor Prism^{RTM} which is connected to the games console **3202** via a serial input socket. Therefore, the operator **3201** can select game functions by pressing the surface of the games console **3202** which enables the operator to interact with a game program running on the electronic processor **3203**. When the operator has finished using the games console **3202** in combination with the electronic processor **3203** the games console may be reconfigured to the first flexible configuration wherein the games console **3202** may be bent about an axis so as to wrap the games console **3202** around the electronic processor **3203** for transportation and storage.

As before, the rigid games console surface enables the operator to use the console in situations where there is no adequate support surface on which to place a flexible device.

Claims

1. A data input device suitable for inputting data to electronic processing means and configured to produce an output in response to a mechanical interaction, wherein

said data input device has a first flexible configuration, in which said device may be bent or flexed about a first axis, and

a second rigid configuration in which said data input device is substantially rigid such that bending or flexing of said device about said first axis is inhibited.

2. A data input device according to claim **1**, wherein the maximum beam thickness of said data input device is larger in said second rigid configuration than in said flexible configuration.

3. A data input device according to any of claims **1** or **2**, wherein, in said first flexible configuration, said device may be reconfigured from an operational configuration in which said electronic processing means is displaced from said keyboard to a wrapped up configuration in which said device is bent about a first and second axis about said electronic processing means.

4. A data input device according to claim **3**, wherein said first and second axis are parallel.

5. A data input device according to any preceding claim, wherein said device comprises a support layer.

6. A data input device according to claim **5**, wherein the maximum beam thickness of said support layer is increased in said second rigid configuration compared to said first flexible configuration.

7. A data input device according to claims **5** or **6**, wherein said support layer is of substantially flat in cross sectional profile in said first flexible configuration and of arched cross-sectional profile in said second rigid configuration.

8. A data input device according to any preceding claim, wherein said device is reconfigured from said first flexible configuration to said second rigid configuration by a reconfiguration means.

9. A data input device according to claim **8**, wherein said reconfiguration means is under-surface layer of said device having a first portion and a second portion separated by a gap having a closure means, said closure means arranged to configure said device in the first flexible configuration when said gap is open and to configure said device in the second rigid configuration when said gap is closed.

10. A data input device according to claim **9**, wherein closure means is a zip fastener.

11. A data input device according any of claims **5** to **10**, wherein said support layer is a semi-flexible sheet of material.

12. A data input device according to any of claims **5** to **10**, wherein said support layer is a layer of semi-flexible material having a plurality of corrugations arranged parallel to said axis of bending.

13. A data input device according to claim **12**, wherein, in said first flexible configuration, said corrugations facilitate bending of said support layer about said first axis.

14. A data input device according to any of claims **5** to **10**, wherein said support layer comprises

a plurality of semi-flexible support rods disposed in a substantially parallel relationship to one another and substantially parallel to said first axis of bending; and

said rods are bound together by a plurality of intertwined fabric fibres.

15. A data input device according to claim **14**, wherein said rods are of larger cross-sectional diameter than said fabric fibres.

16. A data input device according to claim **14** or **15**, wherein said fabric fibres are multi-filament polyester yarns.

17. A data input device according to claims **14** to **16**, wherein, in said second rigid configuration, said semi-flexible rods are disposed in an arched configuration such that bending of said support layer about an axis is inhibited.

18. A data input device according to claims **5** to **10**, wherein said support layer comprises a plurality of support portions.

19. A data input device according to claim **18**, wherein, in said second rigid configuration, each of said portions is of arched cross-sectional profile and in said first flexible configuration, each of said portions is of a substantially flat cross-sectional profile.

20. A data input device according to claim **18** or **19**, wherein said support portions are elongate lengths of sprung steel.

21. A data input device according to any of claims **18** to **20**, wherein said support portions extend substantially perpendicular to the first axis about which said support layer is bent to reconfigure said data input device from an operational configuration to a second rigid configuration.

22. A data input device according to any of claims **18** to **21**, wherein said support portions are mounted onto a fabric sheet.

23. A data input device according to claims **5** to **10**, wherein said support layer is an inflatable compartment.

24. A data input device according to claim **23**, wherein, in said first flexible configuration, said compartment is deflated and, in said second rigid configuration, said compartment is inflated.

25. A data input device according to claim **23** or **24**, wherein said device further comprises an inflation means.

26. A data input device according to claim **25**, wherein said inflation means is a finger pump.

27. A data input device according to any preceding claim, wherein said data input device is a keyboard.

28. A data input device according to any of claims **1** to **26**, wherein said data input device is a games console.

29. A data input device according to any preceding claim, wherein said electronic processor is selected from the group comprising a hand-held electronic processor and a mobile phone.

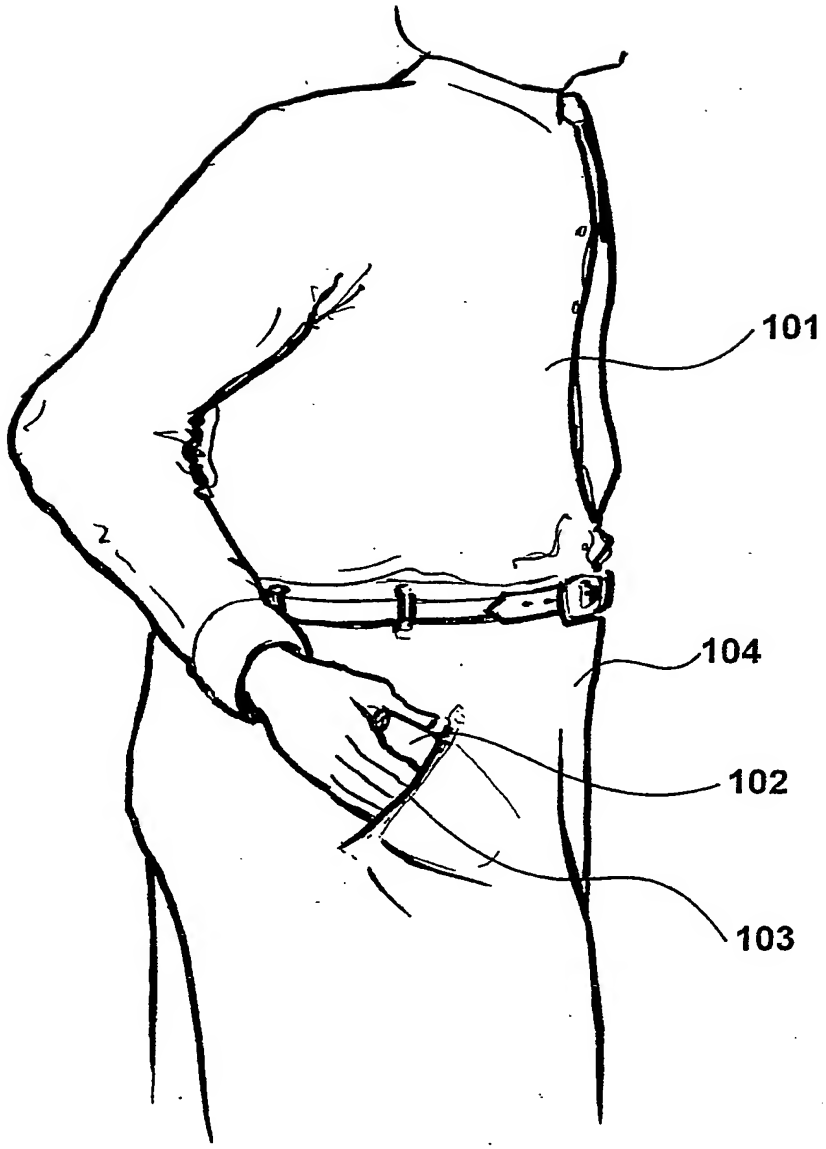

Figure 1

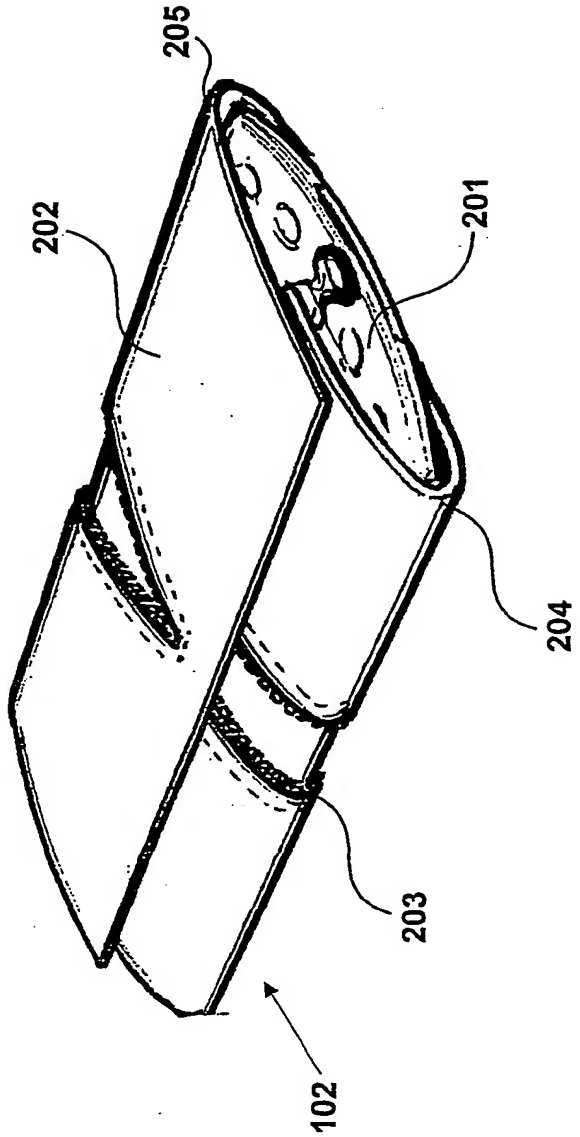

Figure 2

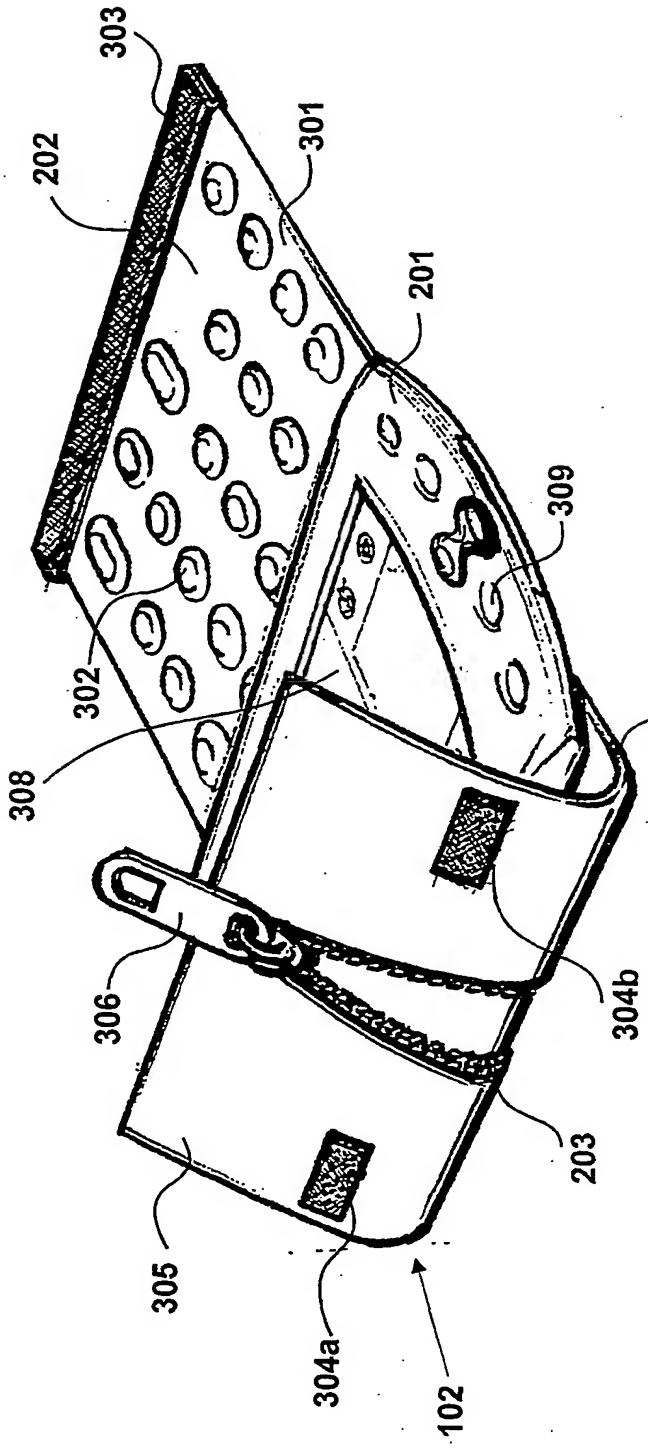

Figure 3

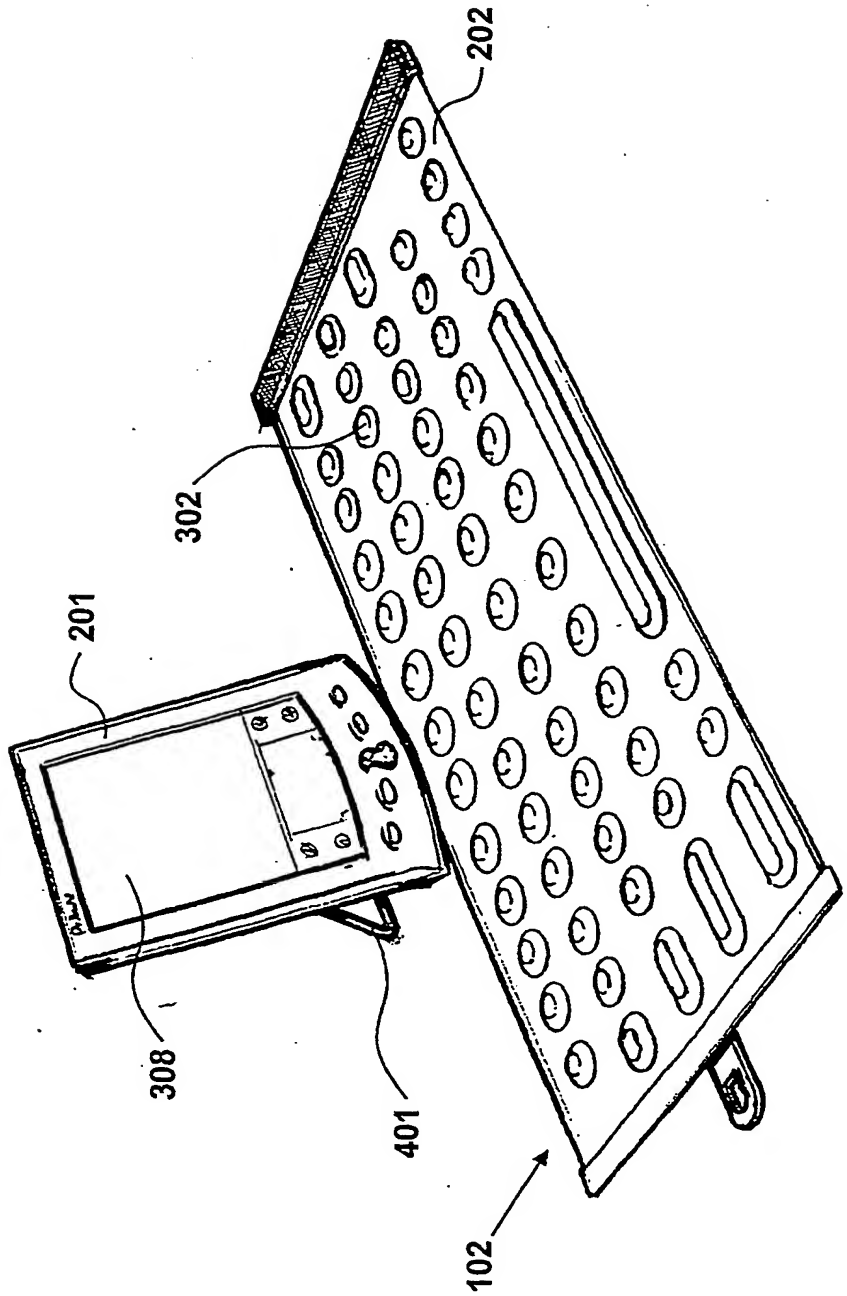

Figure 4

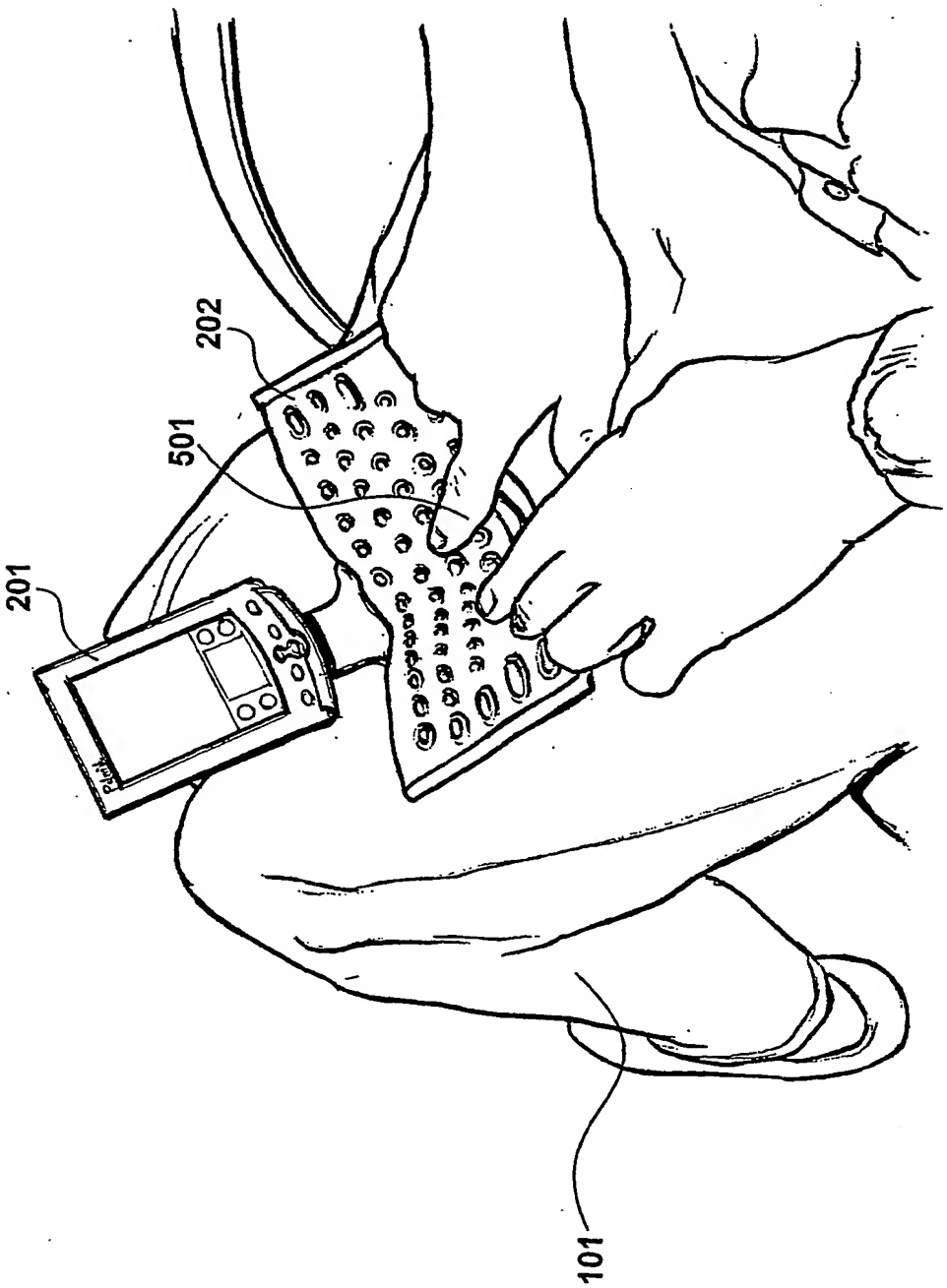

Figure 5

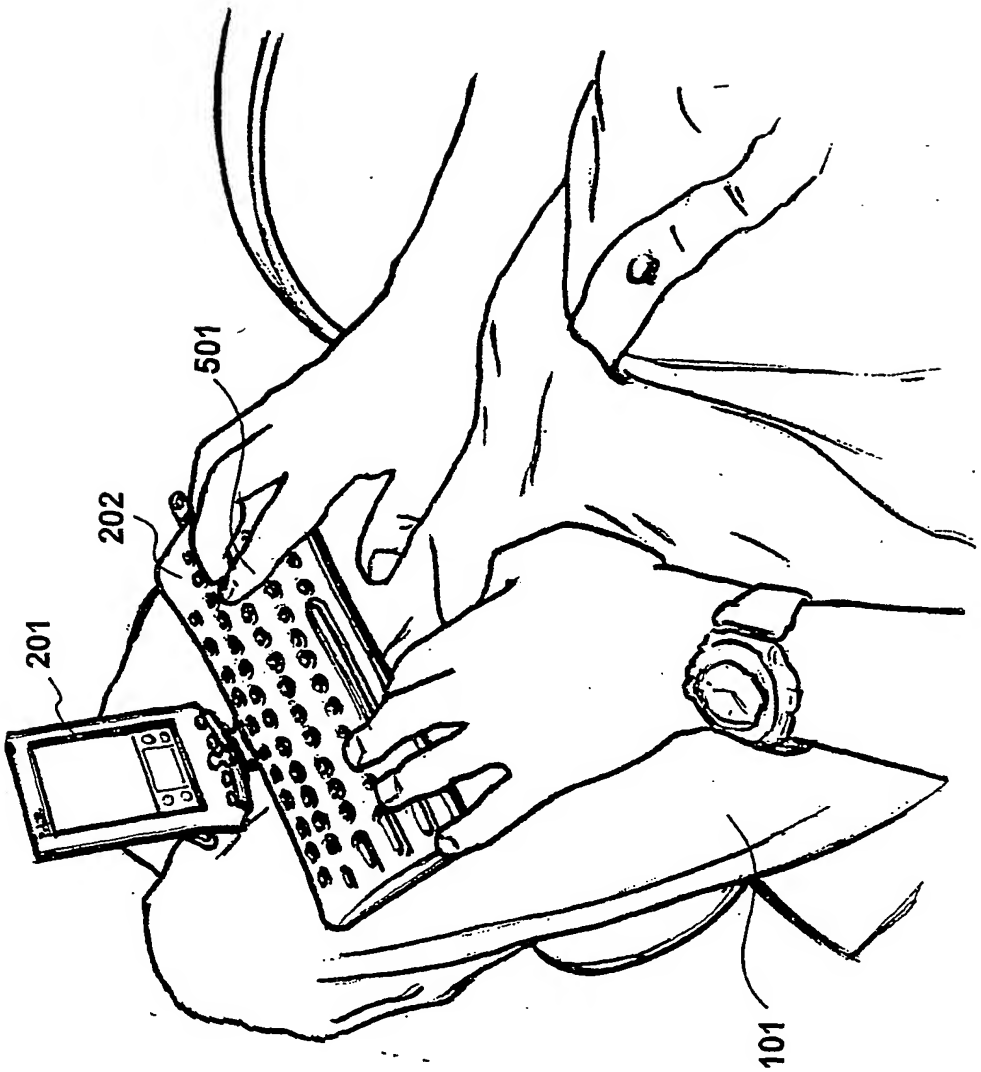

Figure 6

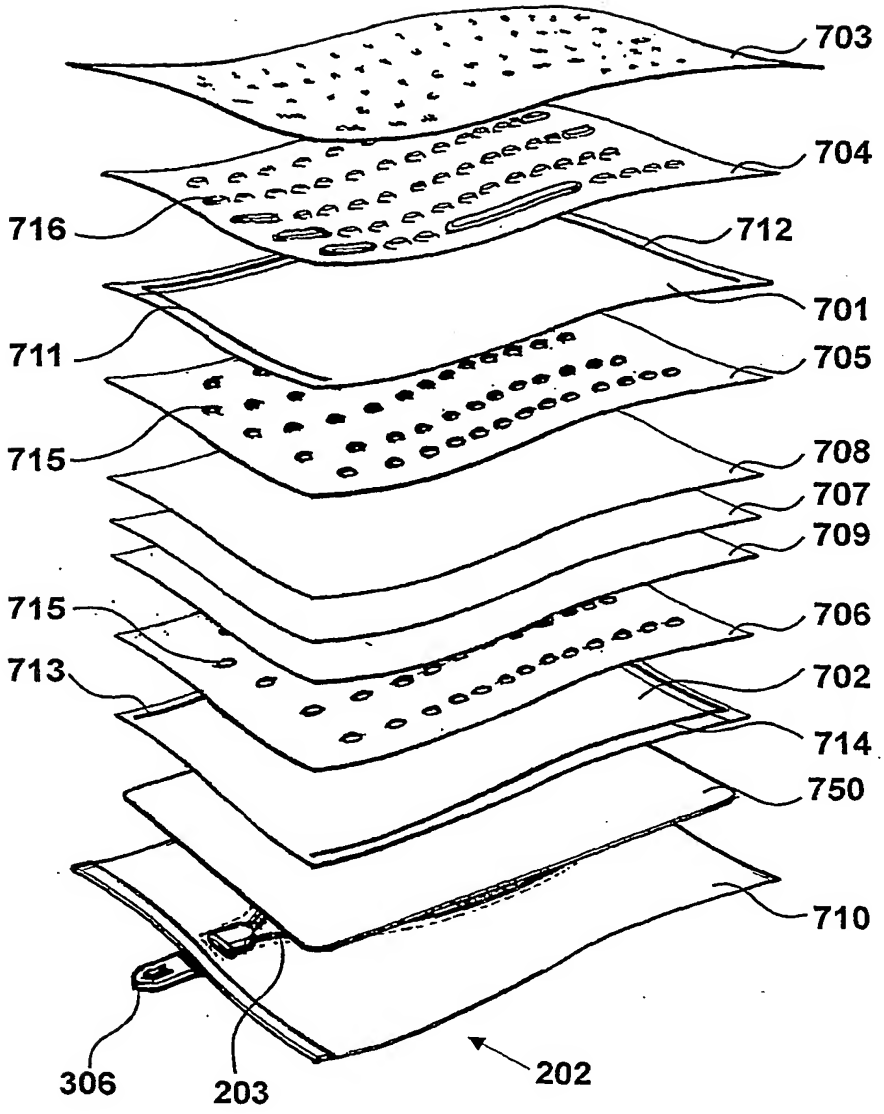
703
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Figure 7

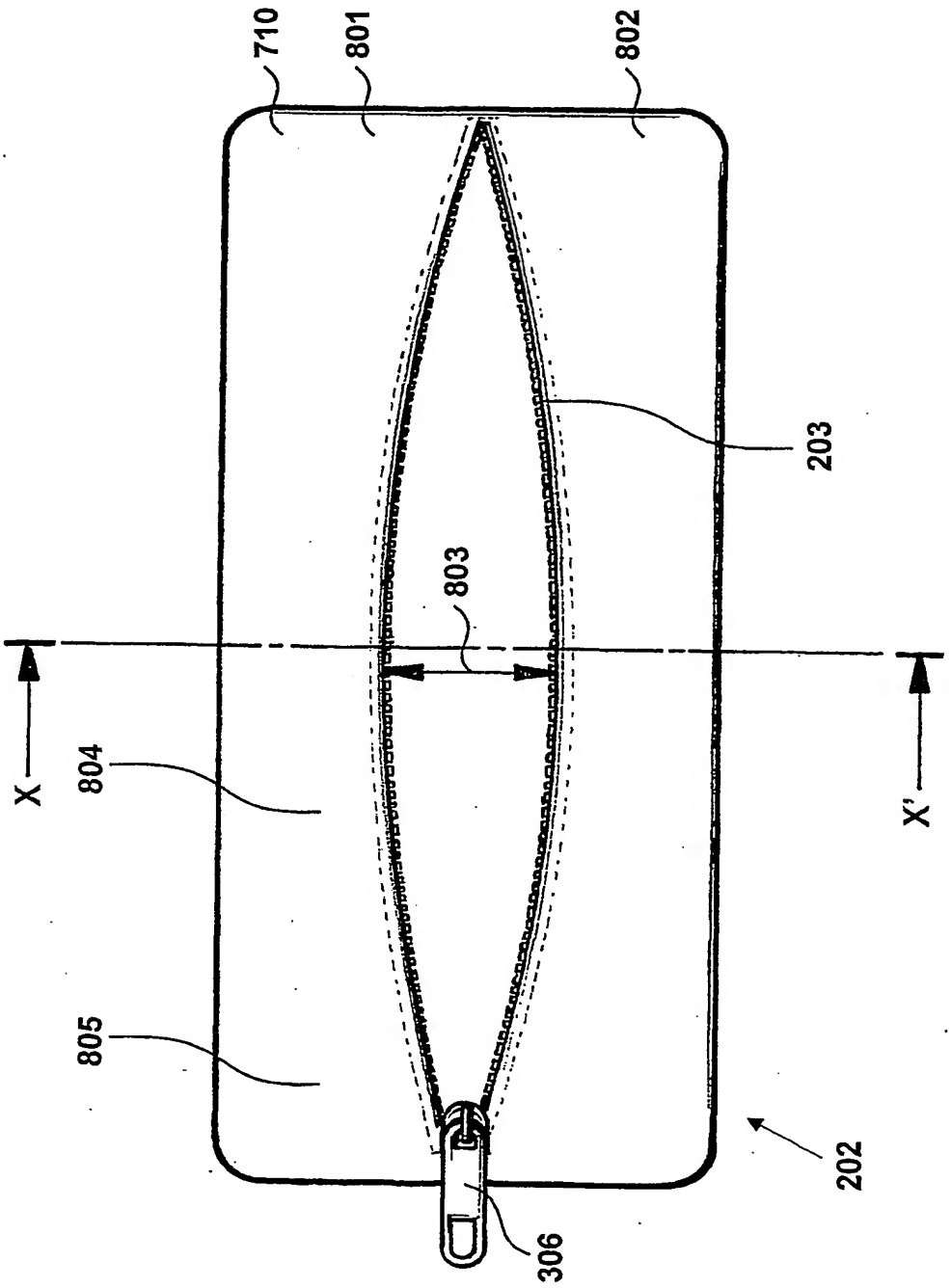

Figure 8A

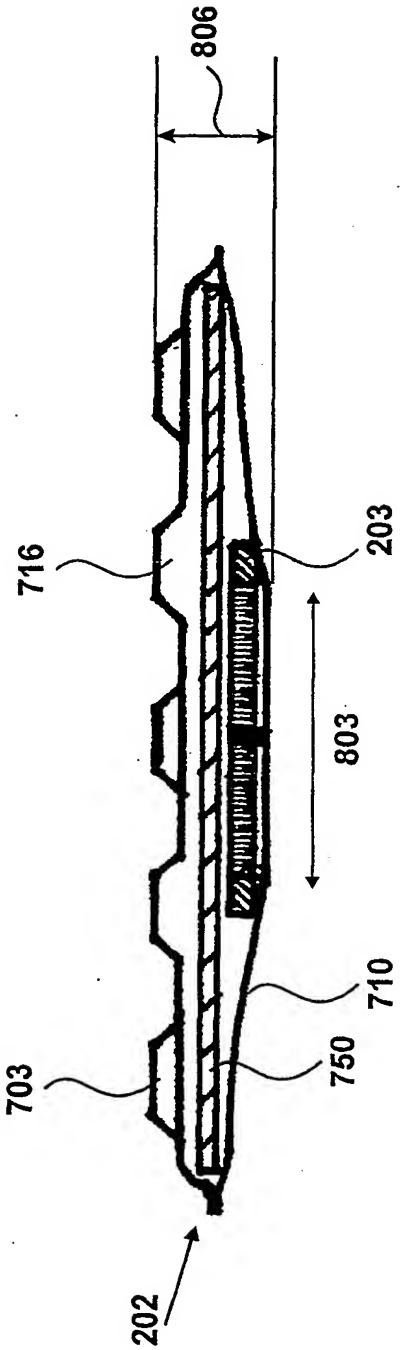

Figure 8B

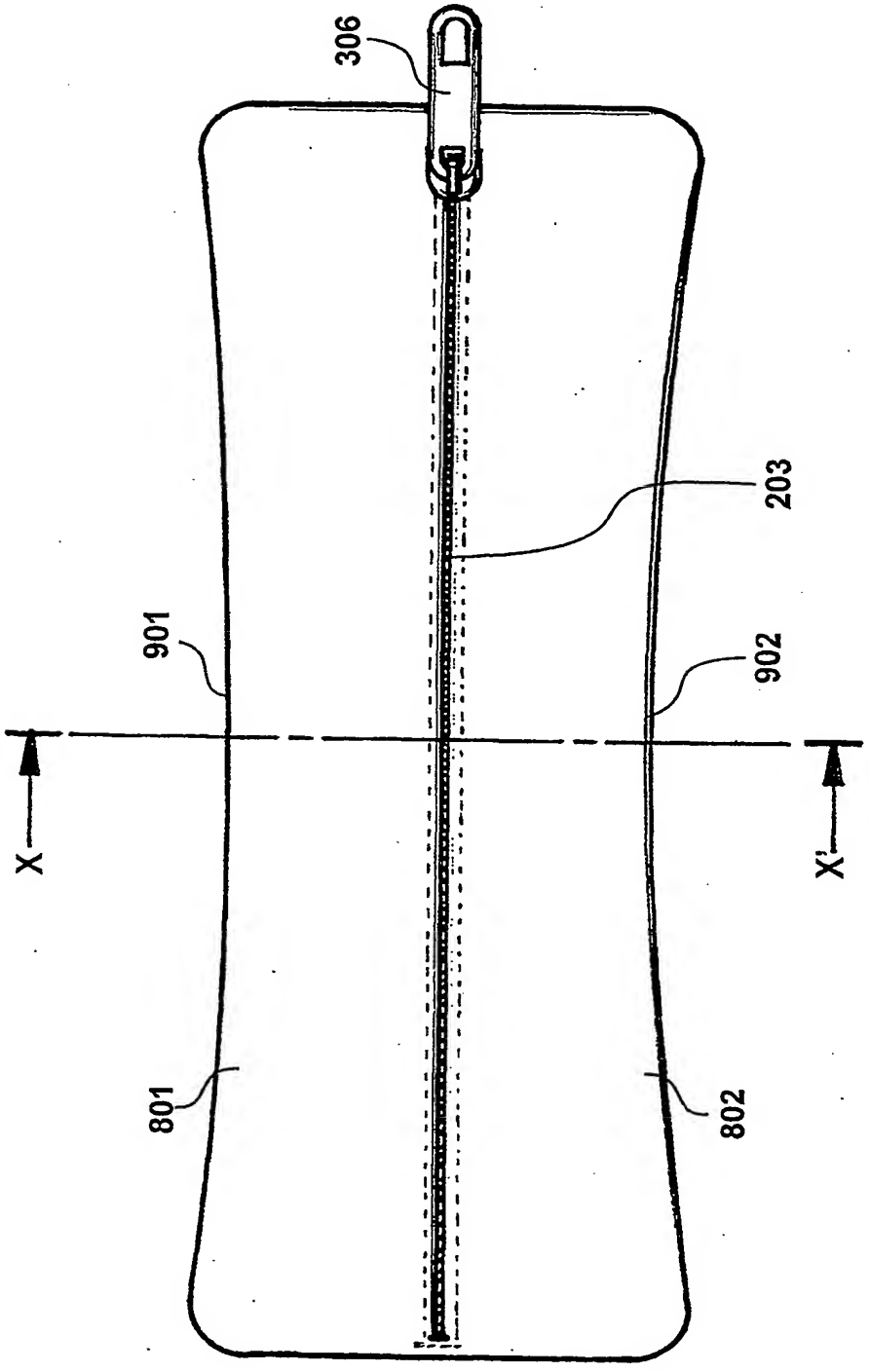

Figure 9A

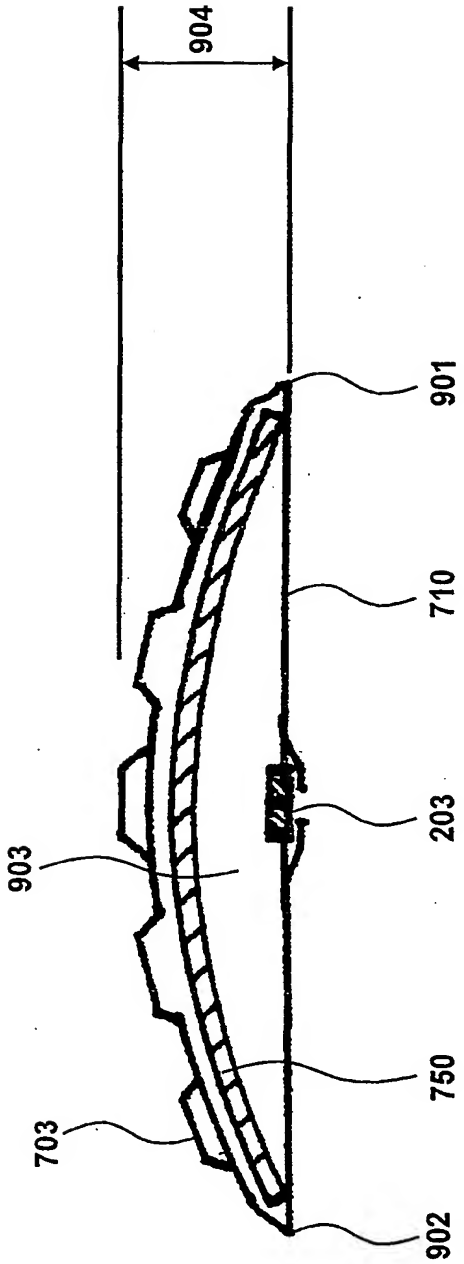

Figure 9B

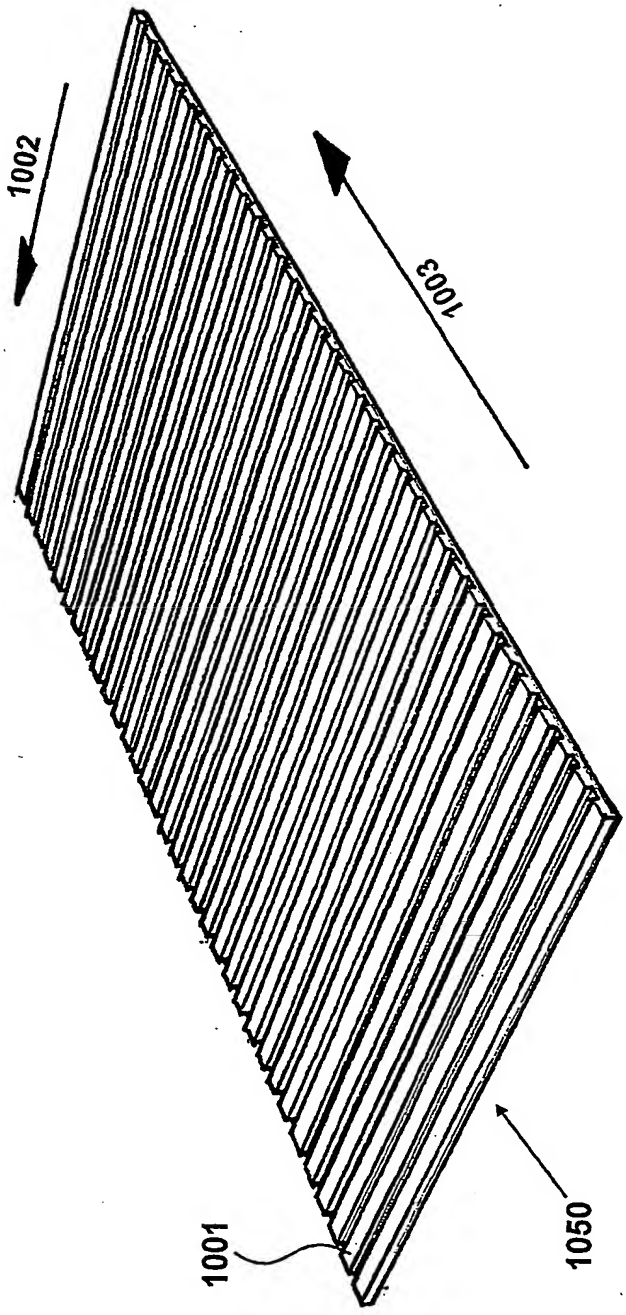

Figure 10

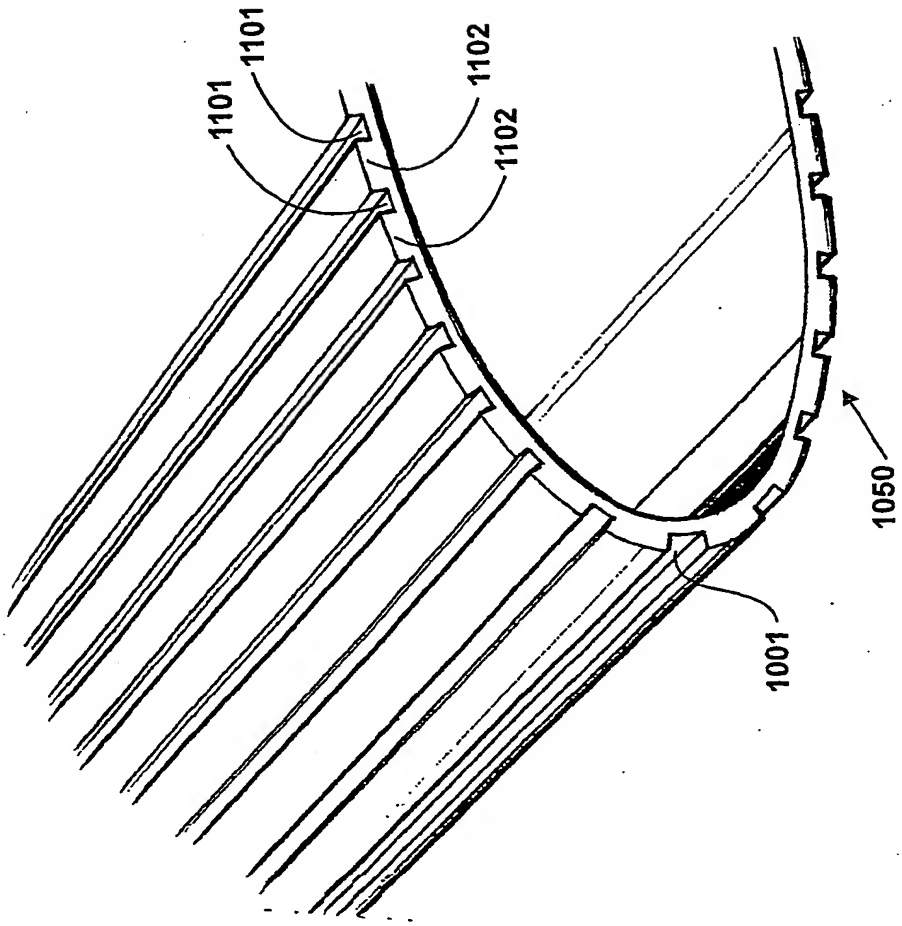

Figure 11

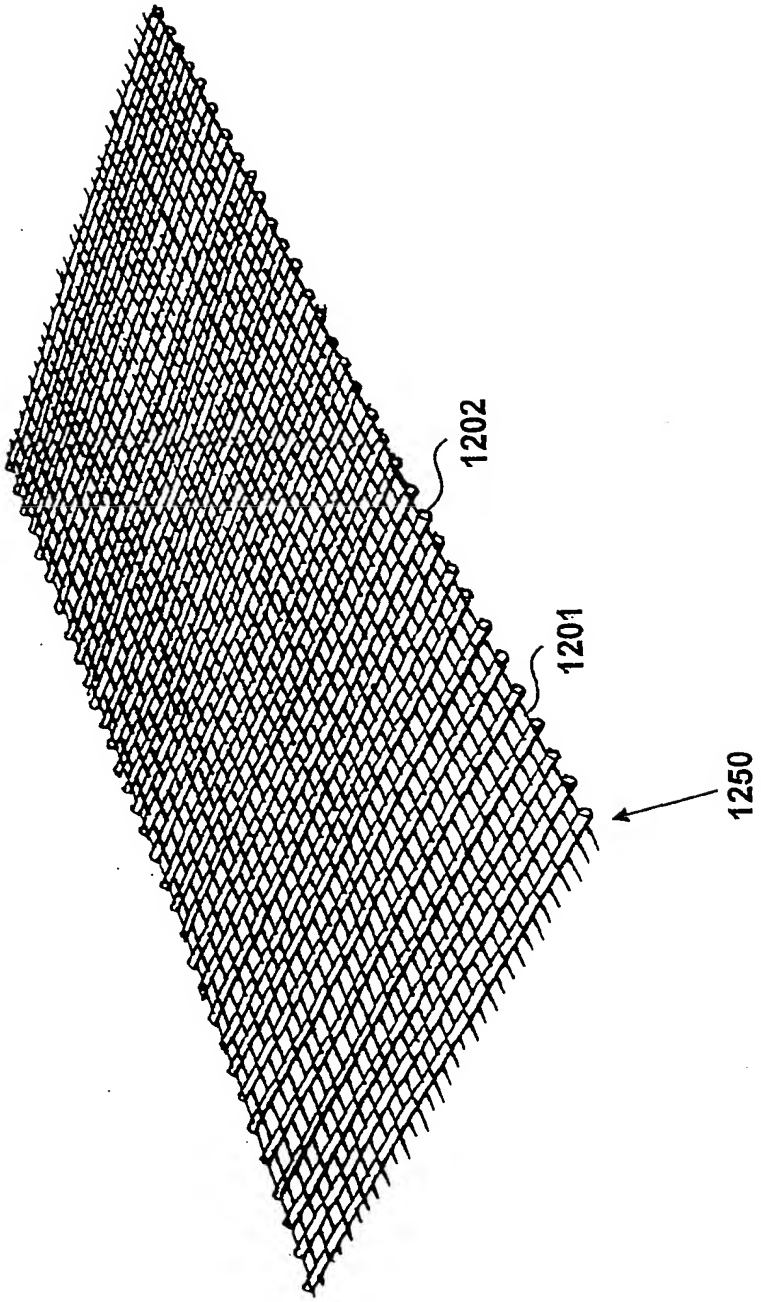

Figure 12

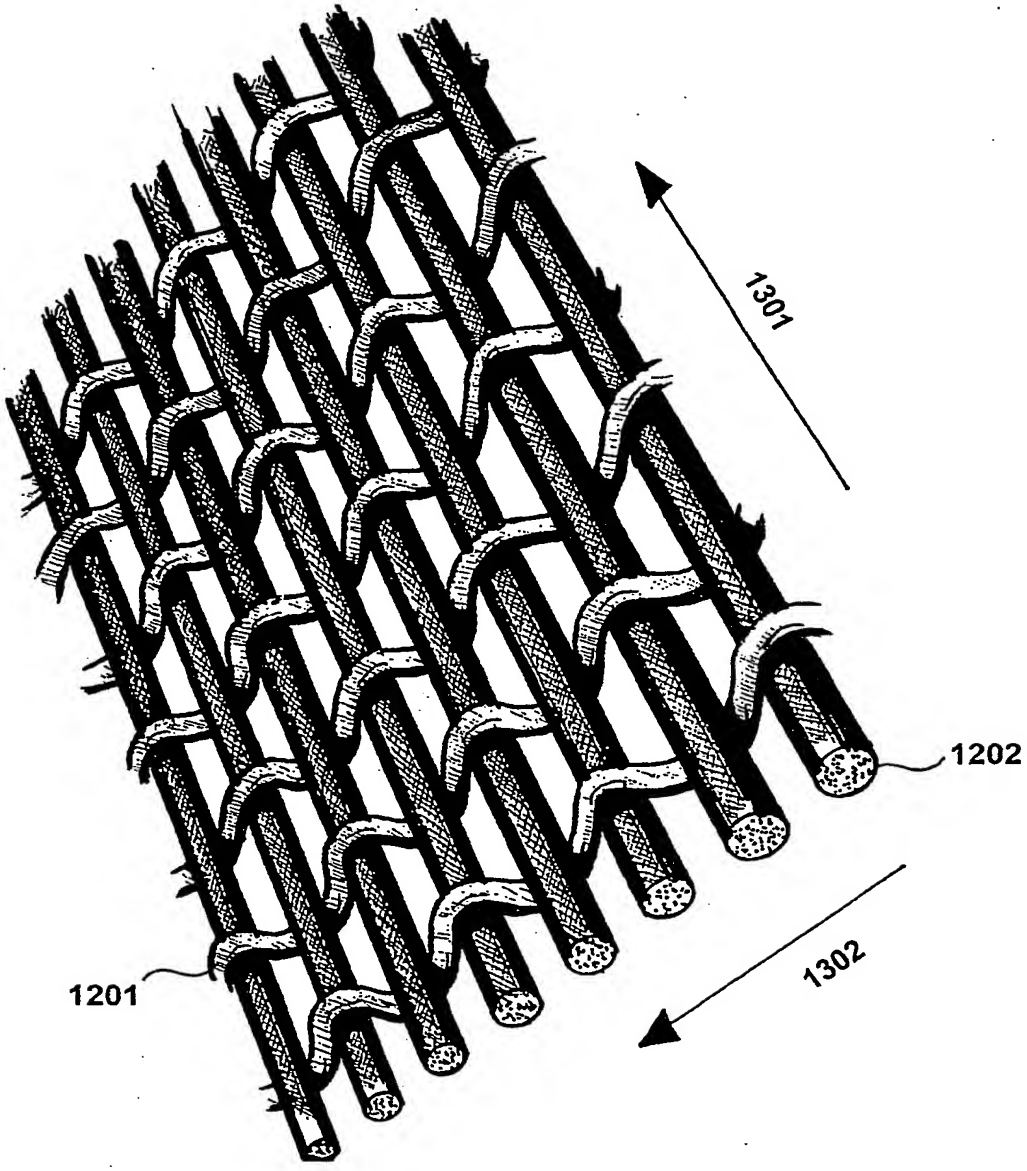

Figure 13

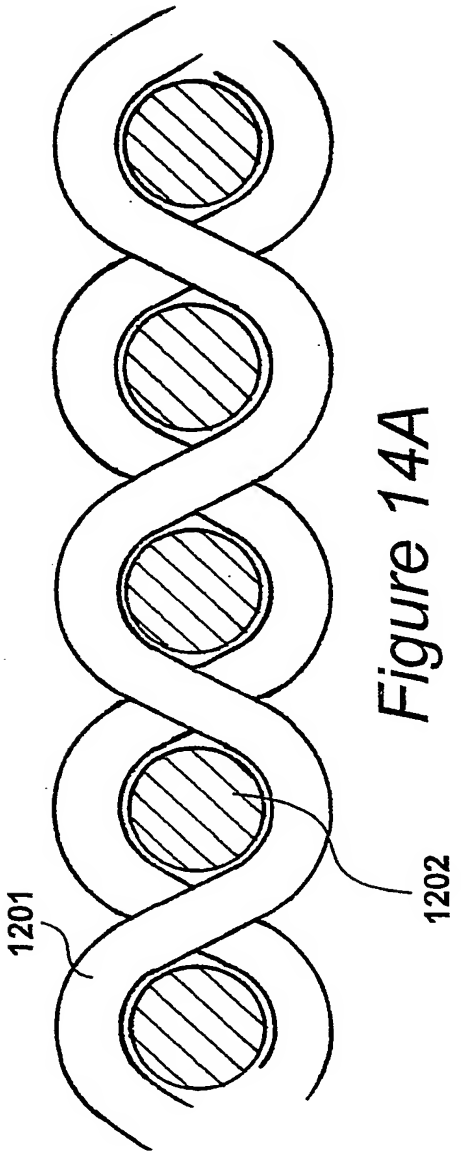

Figure 14A

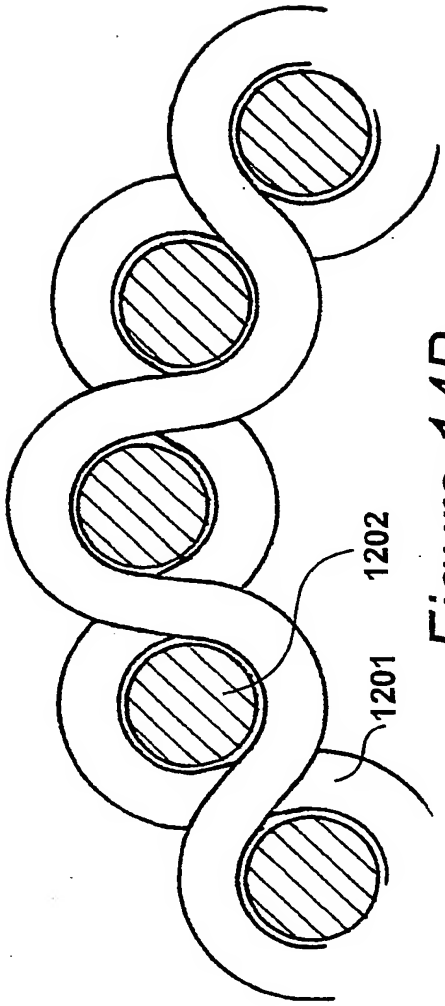

Figure 14B

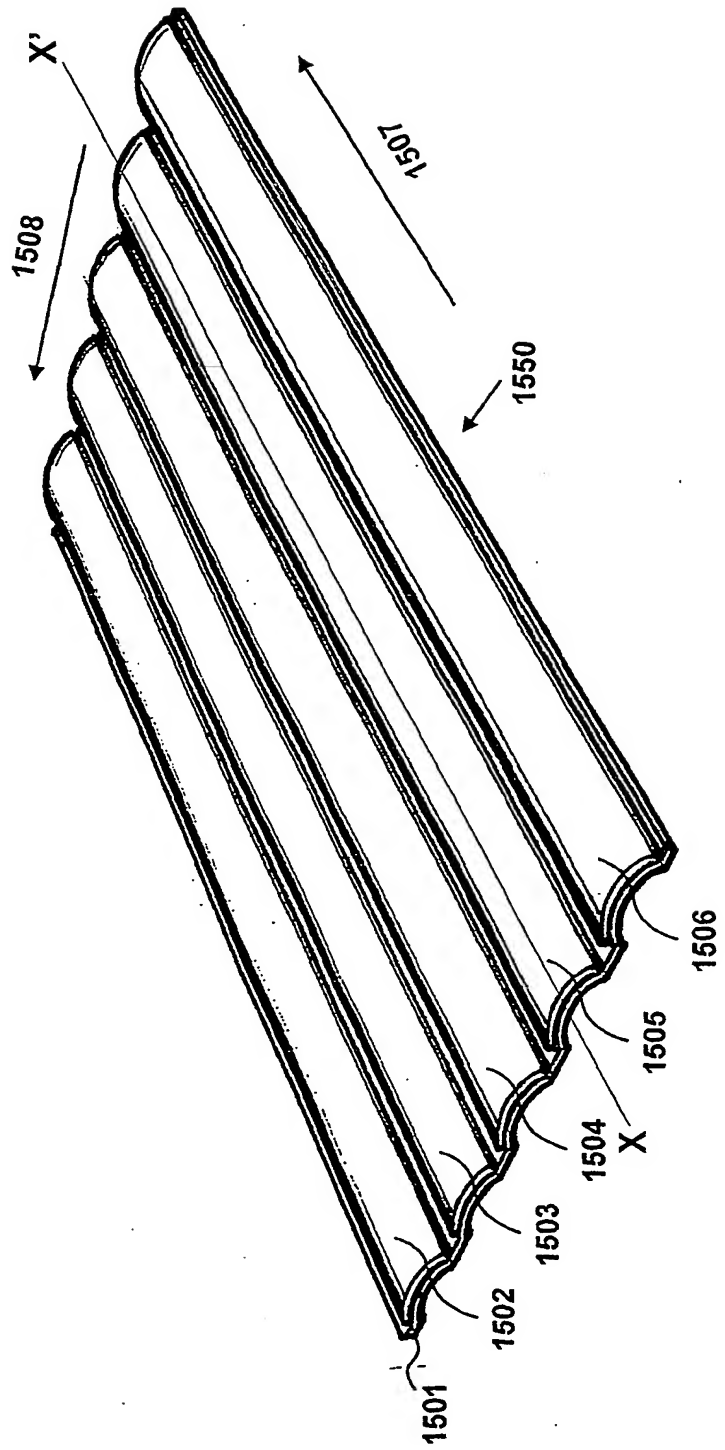

Figure 15

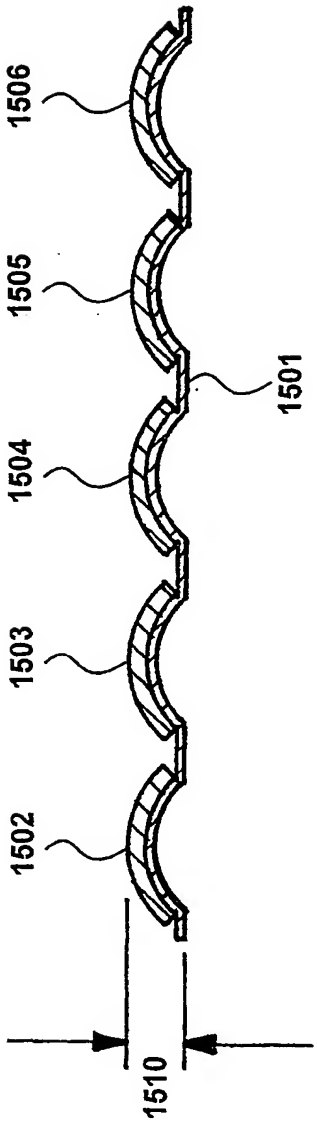

Figure 16

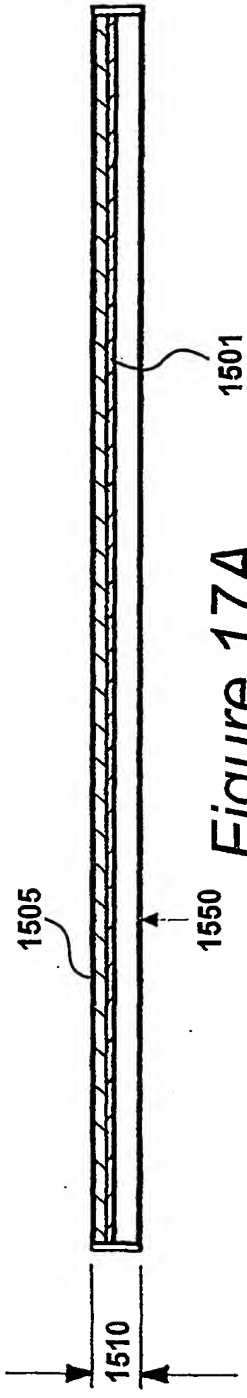

Figure 17A

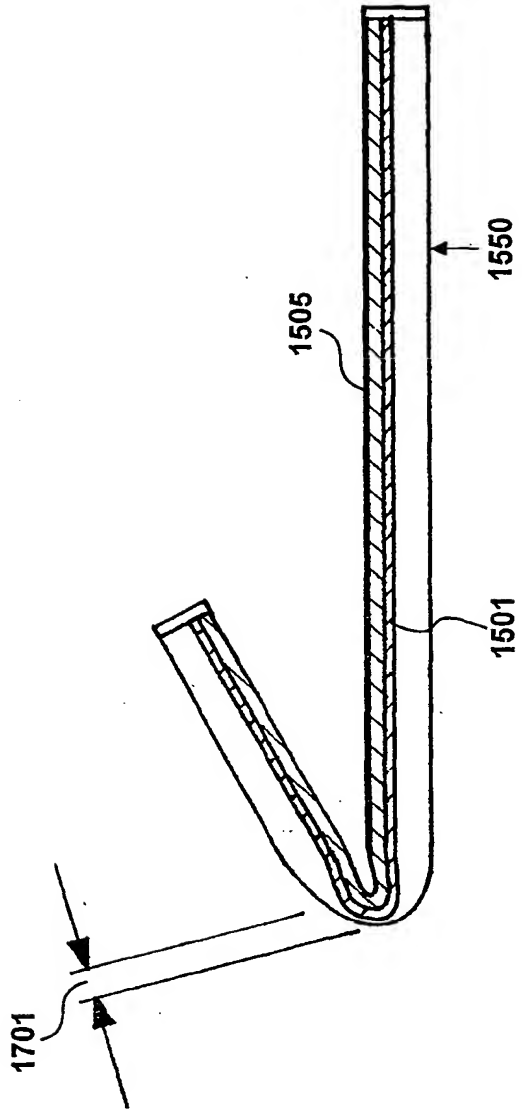

Figure 17B

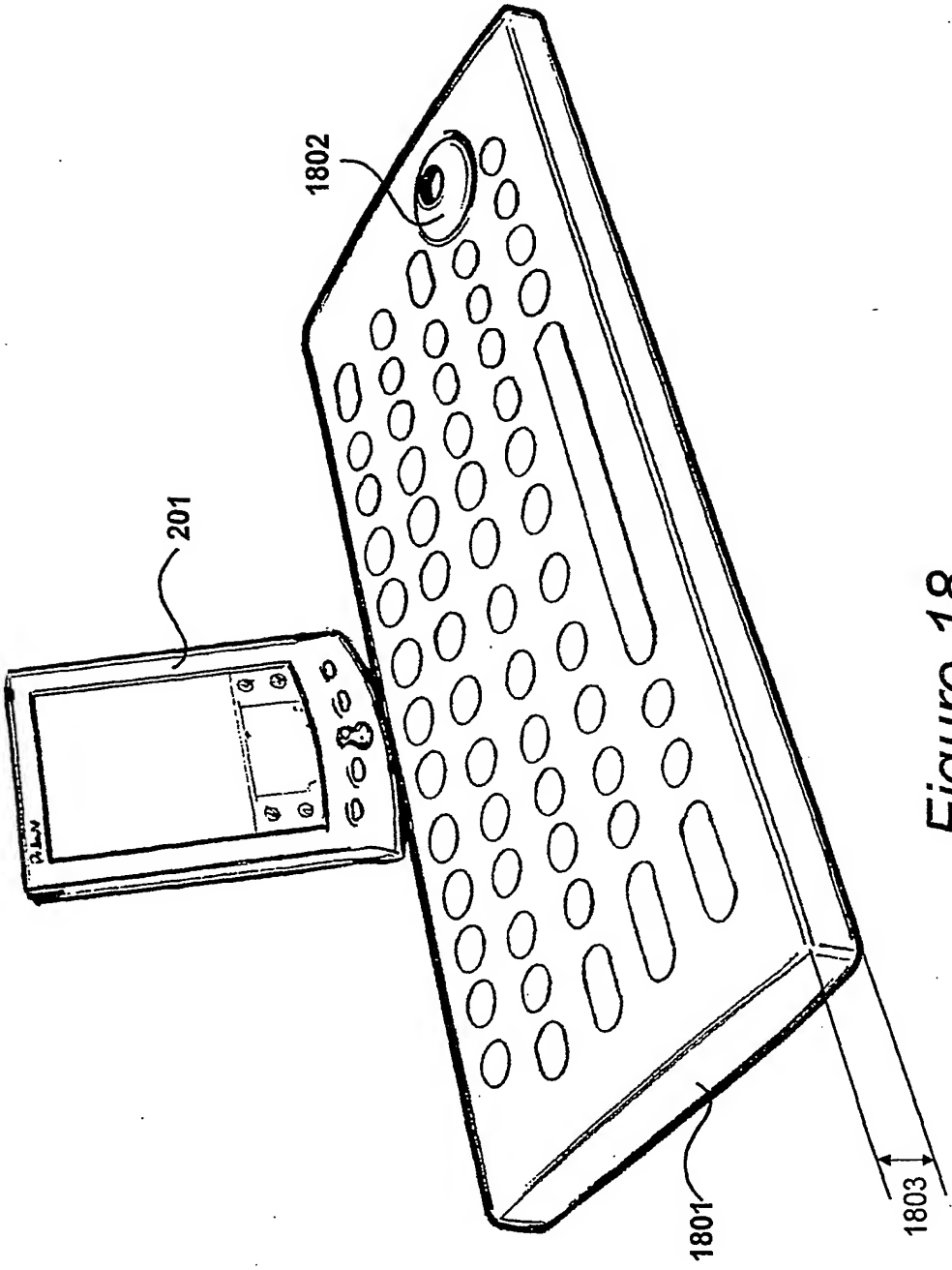

Figure 18

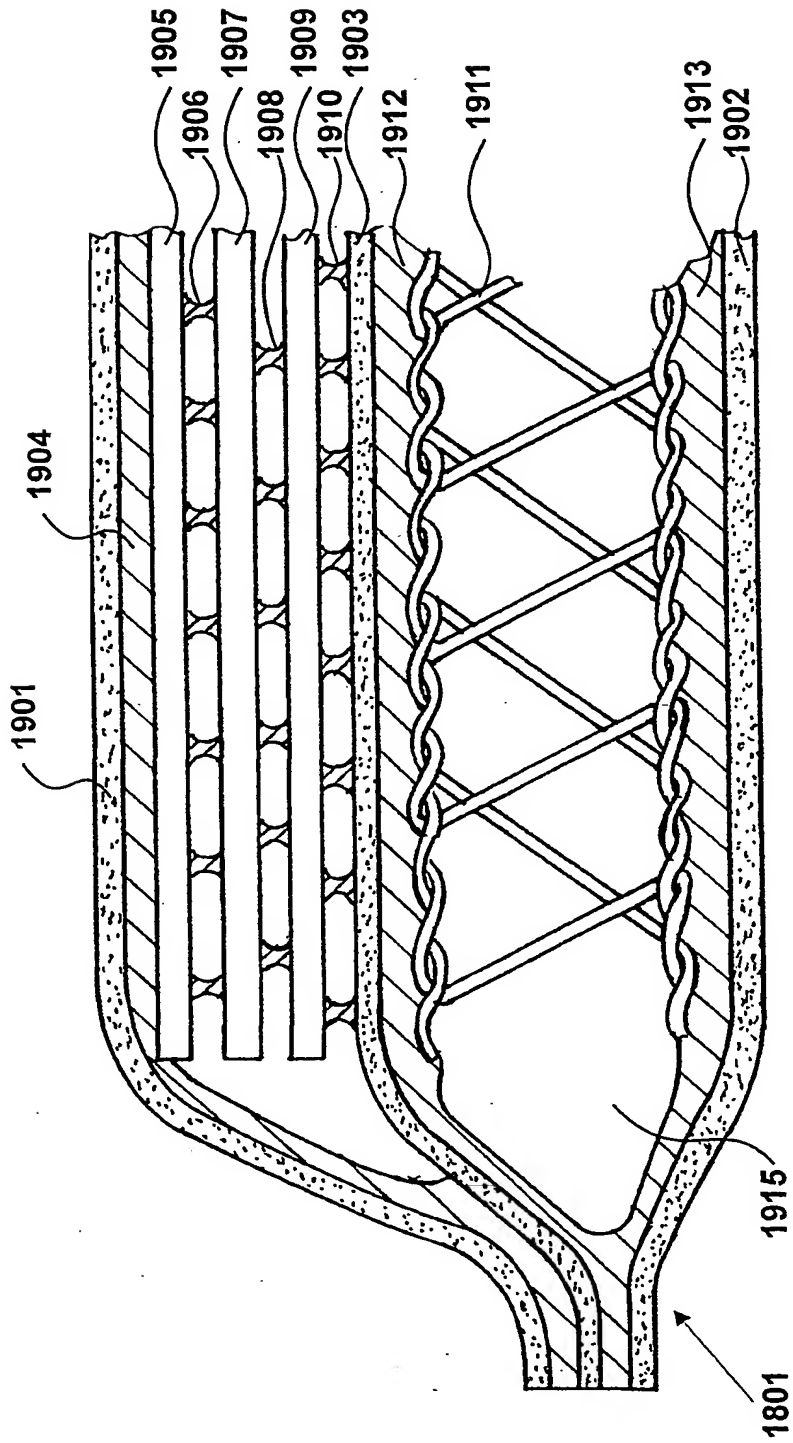
1905
1907
1909
1903
1906
1908
1910
1912
1911
1913
1902
1904
1901
1915
1801

Figure 19

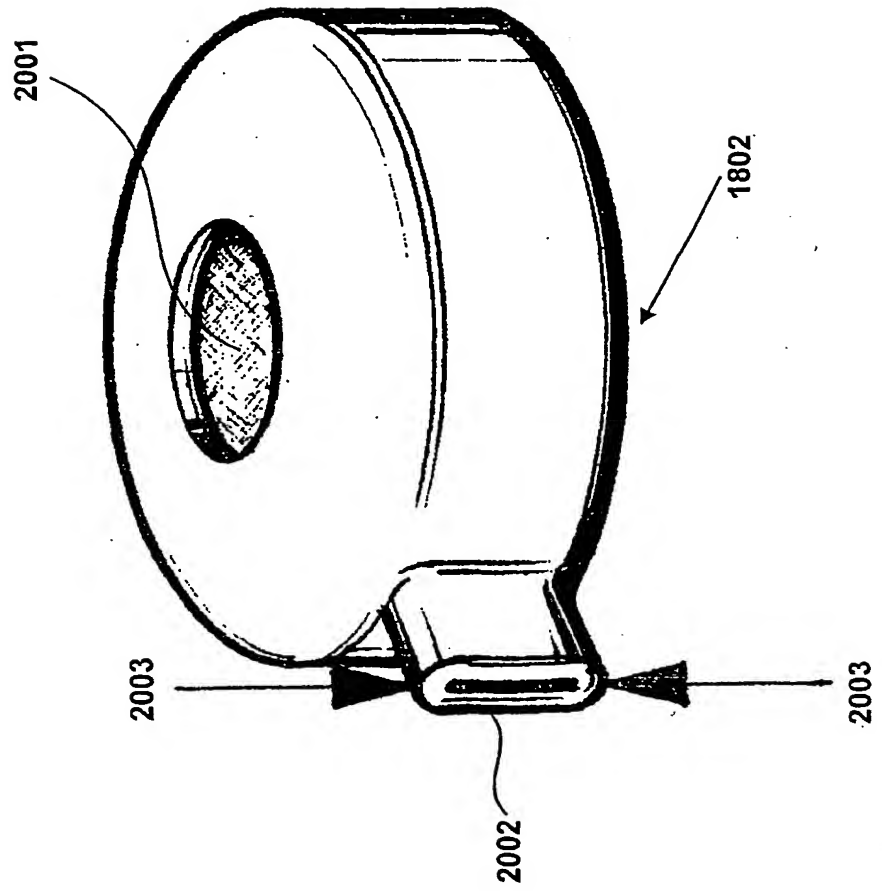

Figure 20

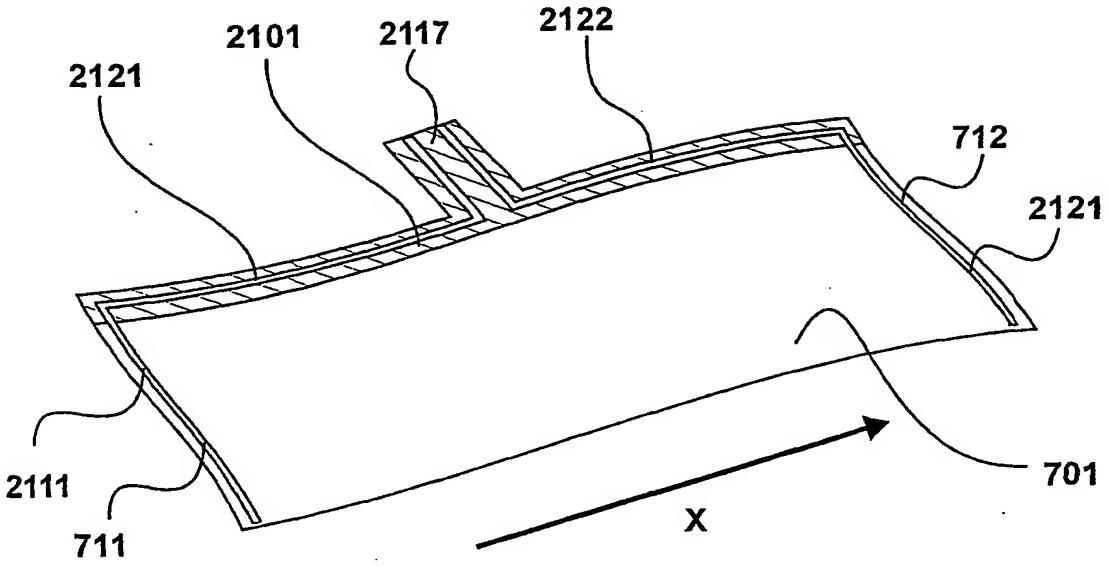

Figure 21A

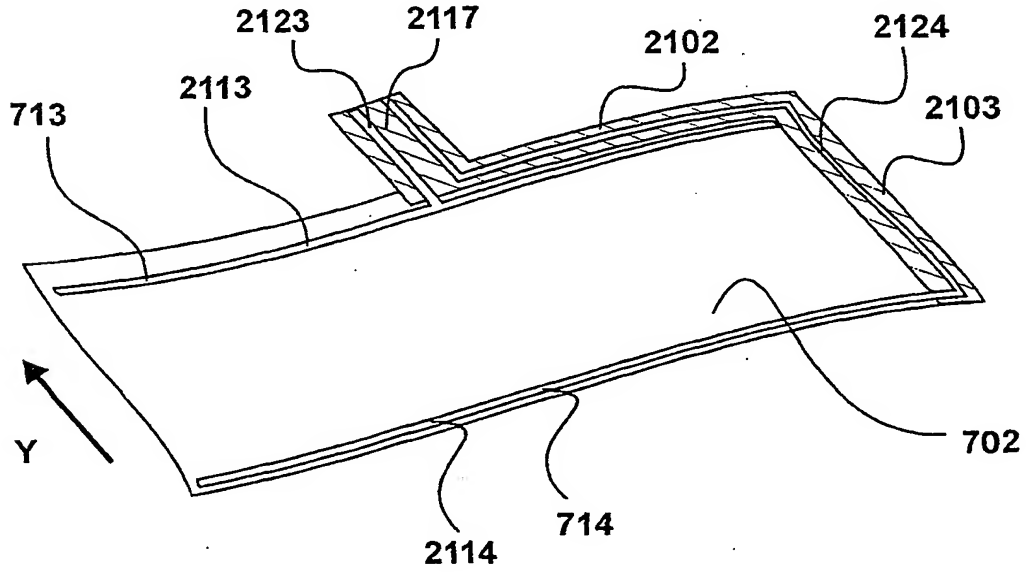

Figure 21B

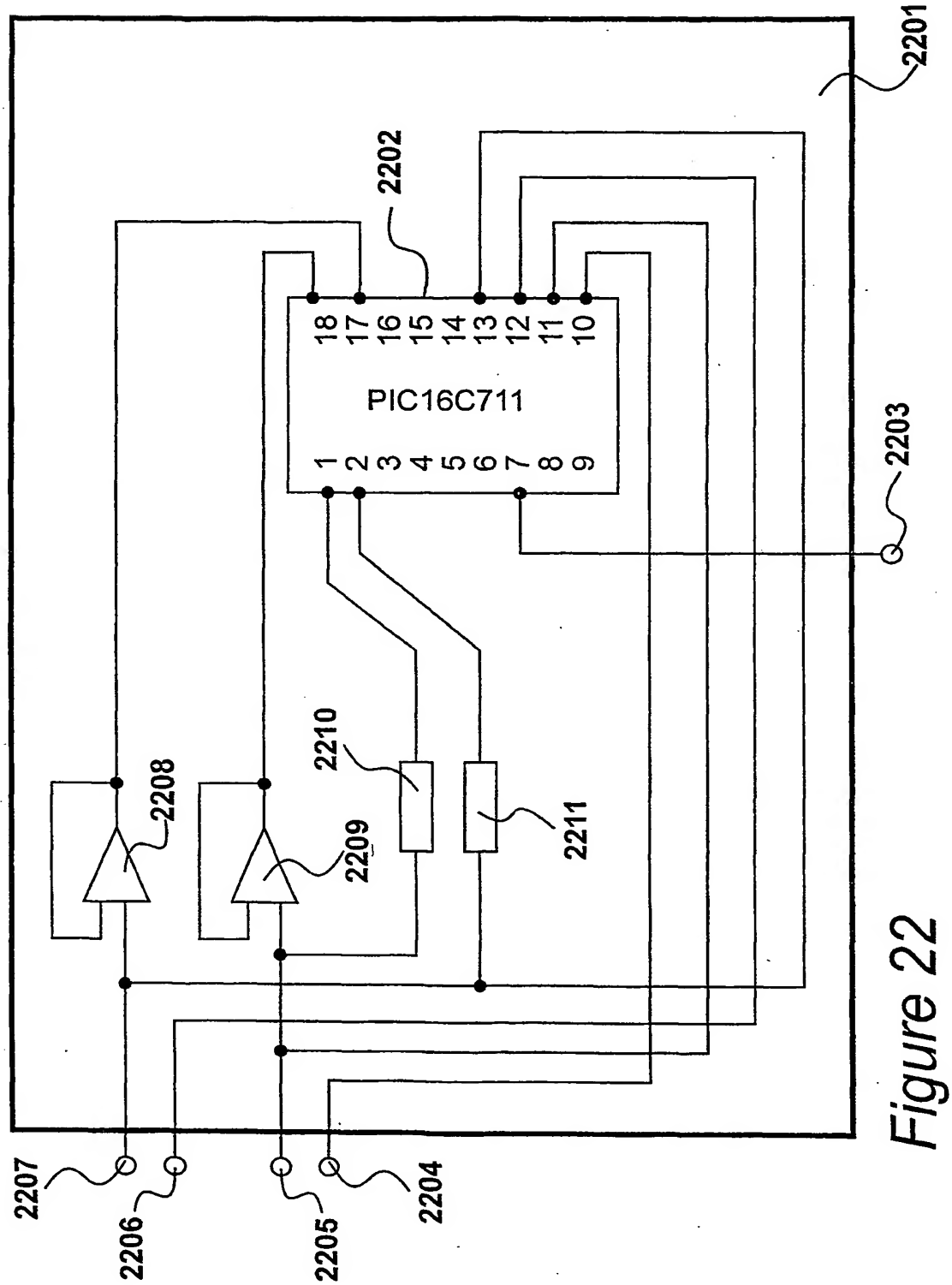
2201
2202
18 17 16 15 14 13 12 11 10
PIC16C711
1 2 3 4 5 6 7 8 9
2203
2208
2209
2210
2211
2207
2206
2205
2204

Figure 22

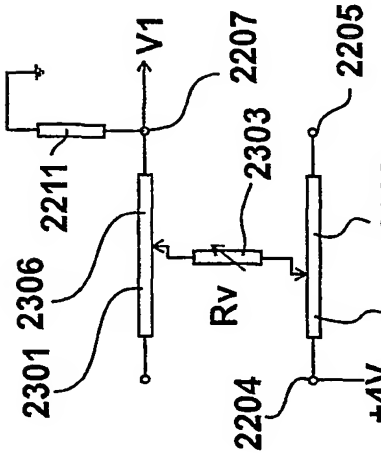

Figure 23A

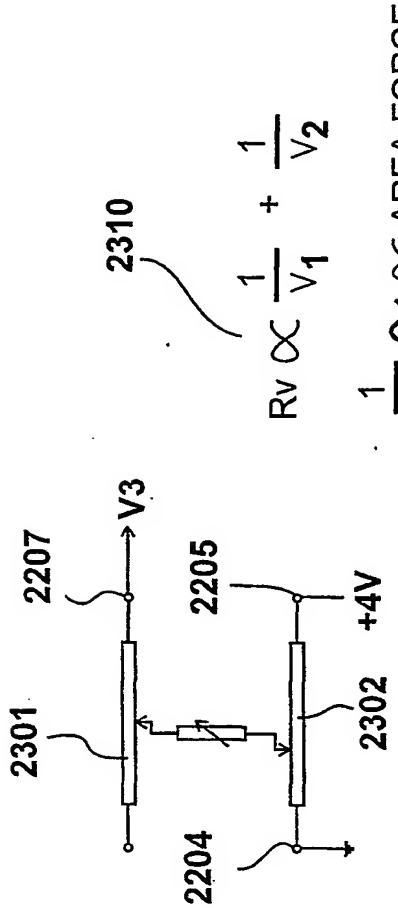

Figure 23C

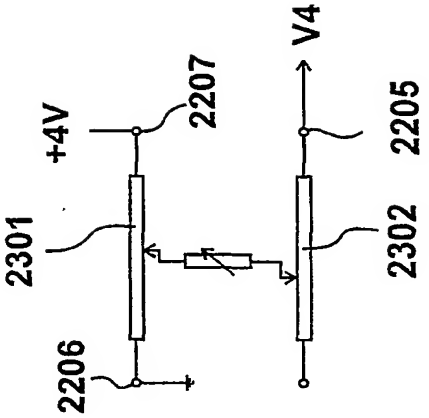

Figure 23D

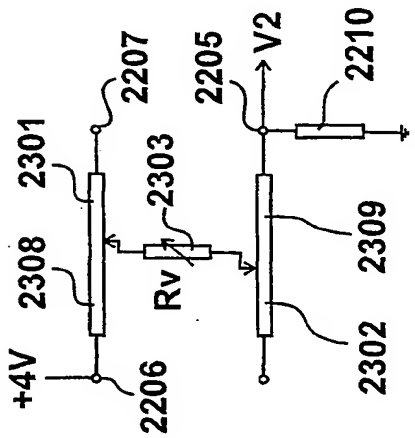

Figure 23B

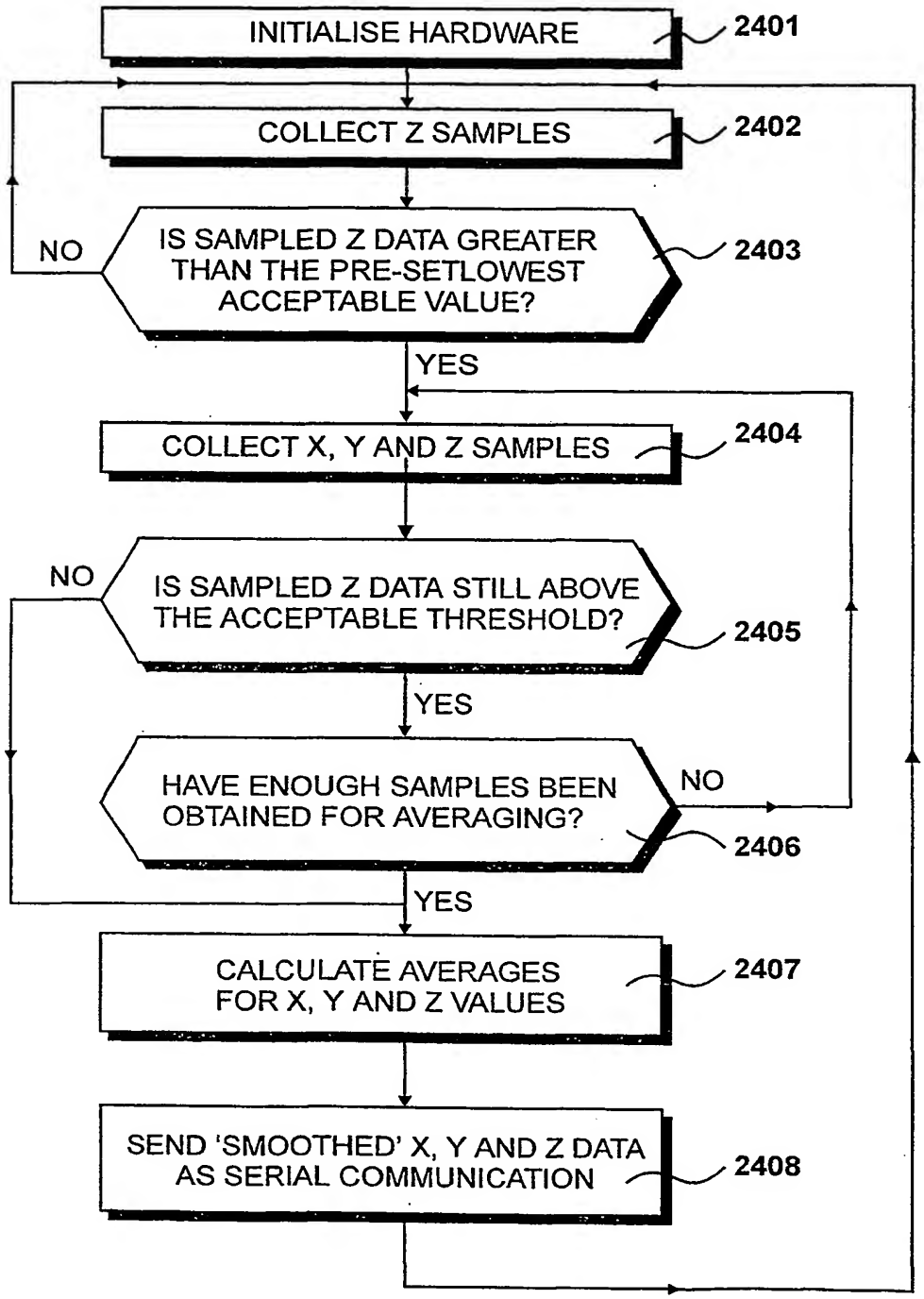
INITIALISE HARDWARE
2401
COLLECT Z SAMPLES
2402
NO
IS SAMPLED Z DATA GREATER THAN THE PRE-SETLOWEST ACCEPTABLE VALUE?
2403
YES
COLLECT X, Y AND Z SAMPLES
2404
NO
IS SAMPLED Z DATA STILL ABOVE THE ACCEPTABLE THRESHOLD?
2405
YES
HAVE ENOUGH SAMPLES BEEN OBTAINED FOR AVERAGING?
NO
2406
YES
CALCULATE AVERAGES FOR X, Y AND Z VALUES
2407
SEND 'SMOOTHED' X, Y AND Z DATA AS SERIAL COMMUNICATION
2408

Figure 24

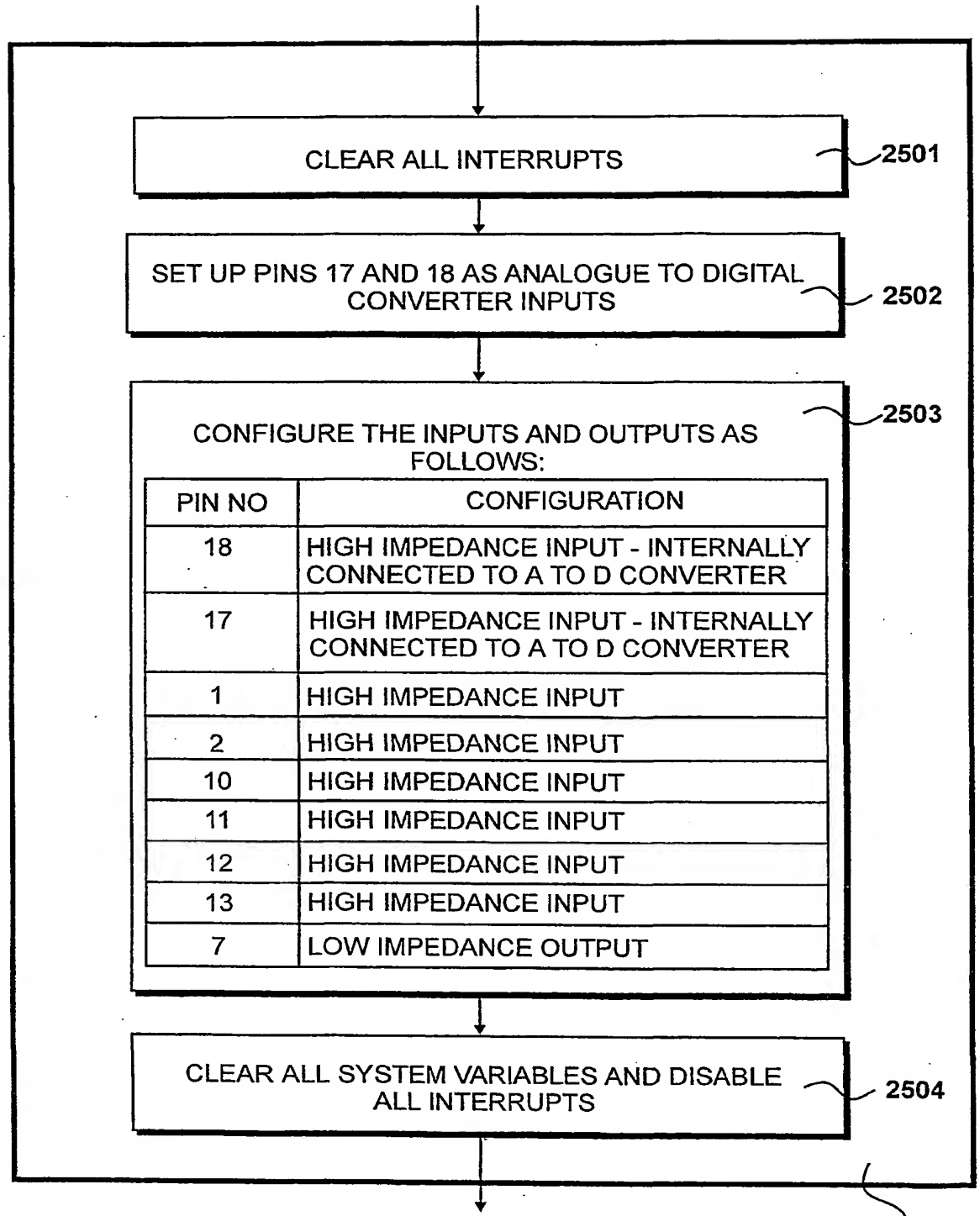
CLEAR ALL INTERRUPTS
2501
SET UP PINS 17 AND 18 AS ANALOGUE TO DIGITAL CONVERTER INPUTS
2502
2503
CONFIGURE THE INPUTS AND OUTPUTS AS FOLLOWS:
PIN NO
CONFIGURATION
18
HIGH IMPEDANCE INPUT - INTERNALLY CONNECTED TO A TO D CONVERTER
17
HIGH IMPEDANCE INPUT - INTERNALLY CONNECTED TO A TO D CONVERTER
1
HIGH IMPEDANCE INPUT
2
HIGH IMPEDANCE INPUT
10
HIGH IMPEDANCE INPUT
11
HIGH IMPEDANCE INPUT
12
HIGH IMPEDANCE INPUT
13
HIGH IMPEDANCE INPUT
7
LOW IMPEDANCE OUTPUT
CLEAR ALL SYSTEM VARIABLES AND DISABLE ALL INTERRUPTS
2504
2401

Figure 25

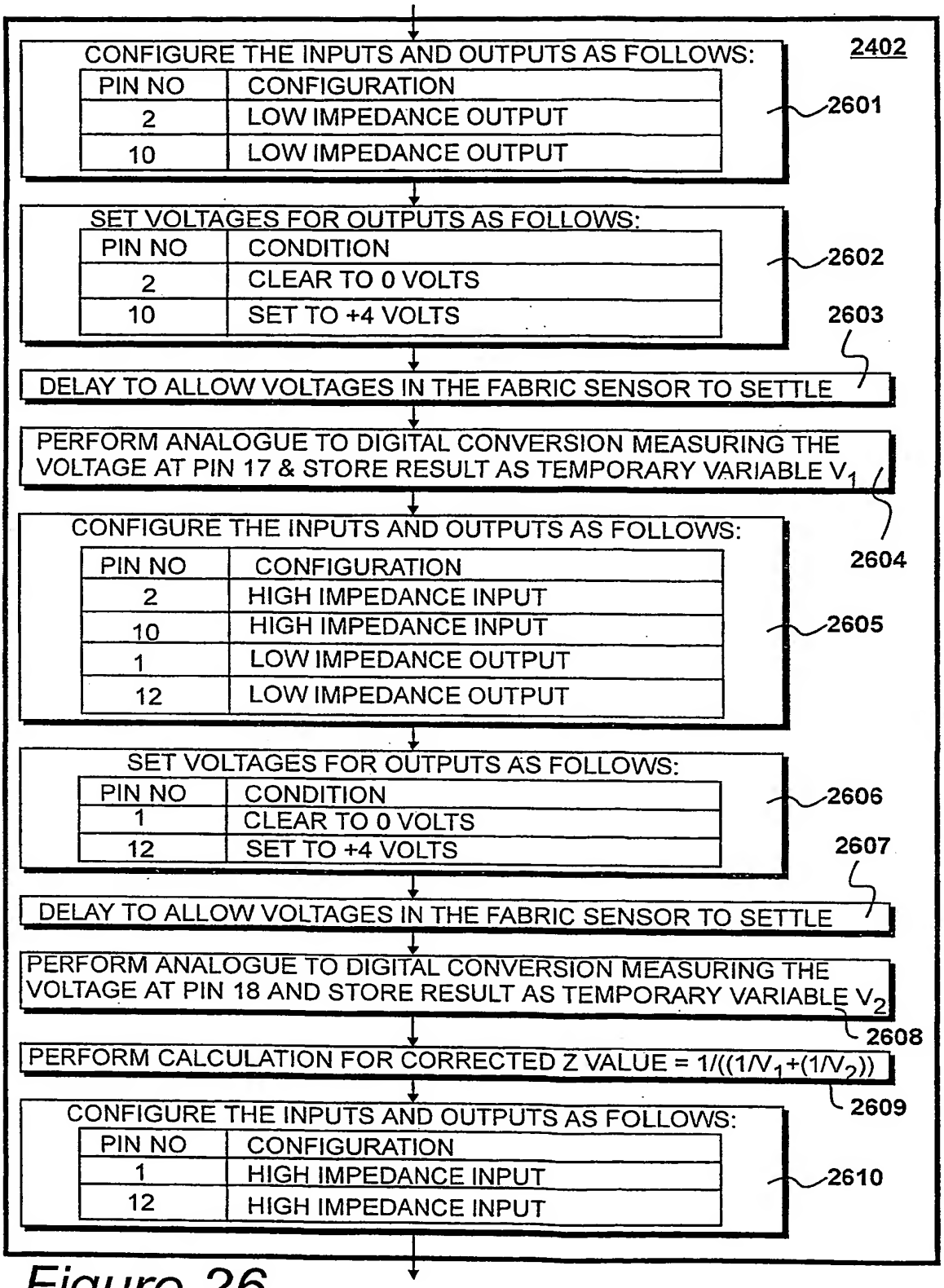
CONFIGURE THE INPUTS AND OUTPUTS AS FOLLOWS:
PIN NO | CONFIGURATION
2 | LOW IMPEDANCE OUTPUT
10 | LOW IMPEDANCE OUTPUT
2402
2601
SET VOLTAGES FOR OUTPUTS AS FOLLOWS:
PIN NO | CONDITION
2 | CLEAR TO 0 VOLTS
10 | SET TO +4 VOLTS
2602
2603
DELAY TO ALLOW VOLTAGES IN THE FABRIC SENSOR TO SETTLE
PERFORM ANALOGUE TO DIGITAL CONVERSION MEASURING THE VOLTAGE AT PIN 17 & STORE RESULT AS TEMPORARY VARIABLE V1
2604
CONFIGURE THE INPUTS AND OUTPUTS AS FOLLOWS:
PIN NO | CONFIGURATION
2 | HIGH IMPEDANCE INPUT
10 | HIGH IMPEDANCE INPUT
1 | LOW IMPEDANCE OUTPUT
12 | LOW IMPEDANCE OUTPUT
2605
SET VOLTAGES FOR OUTPUTS AS FOLLOWS:
PIN NO | CONDITION
1 | CLEAR TO 0 VOLTS
12 | SET TO +4 VOLTS
2606
2607
DELAY TO ALLOW VOLTAGES IN THE FABRIC SENSOR TO SETTLE
PERFORM ANALOGUE TO DIGITAL CONVERSION MEASURING THE VOLTAGE AT PIN 18 AND STORE RESULT AS TEMPORARY VARIABLE V2
2608
PERFORM CALCULATION FOR CORRECTED Z VALUE = 1/((1/V1+(1/V2))
2609
CONFIGURE THE INPUTS AND OUTPUTS AS FOLLOWS:
PIN NO | CONFIGURATION
1 | HIGH IMPEDANCE INPUT
12 | HIGH IMPEDANCE INPUT
2610

Figure 26

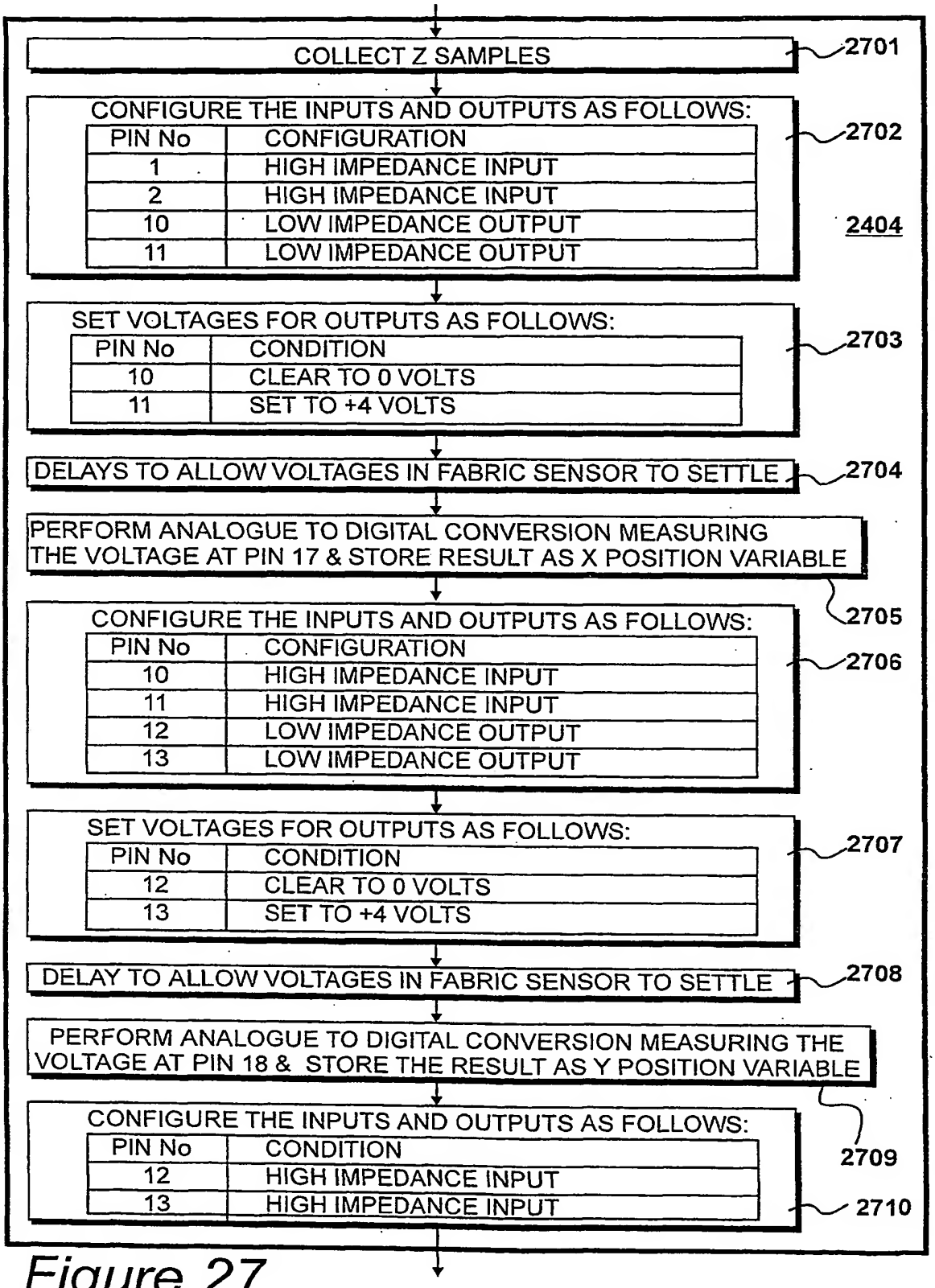
COLLECT Z SAMPLES
2701
CONFIGURE THE INPUTS AND OUTPUTS AS FOLLOWS:
PIN No | CONFIGURATION
1 | HIGH IMPEDANCE INPUT
2 | HIGH IMPEDANCE INPUT
10 | LOW IMPEDANCE OUTPUT
11 | LOW IMPEDANCE OUTPUT
2702
2404
SET VOLTAGES FOR OUTPUTS AS FOLLOWS:
PIN No | CONDITION
10 | CLEAR TO 0 VOLTS
11 | SET TO +4 VOLTS
2703
DELAYS TO ALLOW VOLTAGES IN FABRIC SENSOR TO SETTLE
2704
PERFORM ANALOGUE TO DIGITAL CONVERSION MEASURING THE VOLTAGE AT PIN 17 & STORE RESULT AS X POSITION VARIABLE
2705
CONFIGURE THE INPUTS AND OUTPUTS AS FOLLOWS:
PIN No | CONFIGURATION
10 | HIGH IMPEDANCE INPUT
11 | HIGH IMPEDANCE INPUT
12 | LOW IMPEDANCE OUTPUT
13 | LOW IMPEDANCE OUTPUT
2706
SET VOLTAGES FOR OUTPUTS AS FOLLOWS:
PIN No | CONDITION
12 | CLEAR TO 0 VOLTS
13 | SET TO +4 VOLTS
2707
DELAY TO ALLOW VOLTAGES IN FABRIC SENSOR TO SETTLE
2708
PERFORM ANALOGUE TO DIGITAL CONVERSION MEASURING THE VOLTAGE AT PIN 18 & STORE THE RESULT AS Y POSITION VARIABLE
2709
CONFIGURE THE INPUTS AND OUTPUTS AS FOLLOWS:
PIN No | CONDITION
12 | HIGH IMPEDANCE INPUT
13 | HIGH IMPEDANCE INPUT
2710

Figure 27

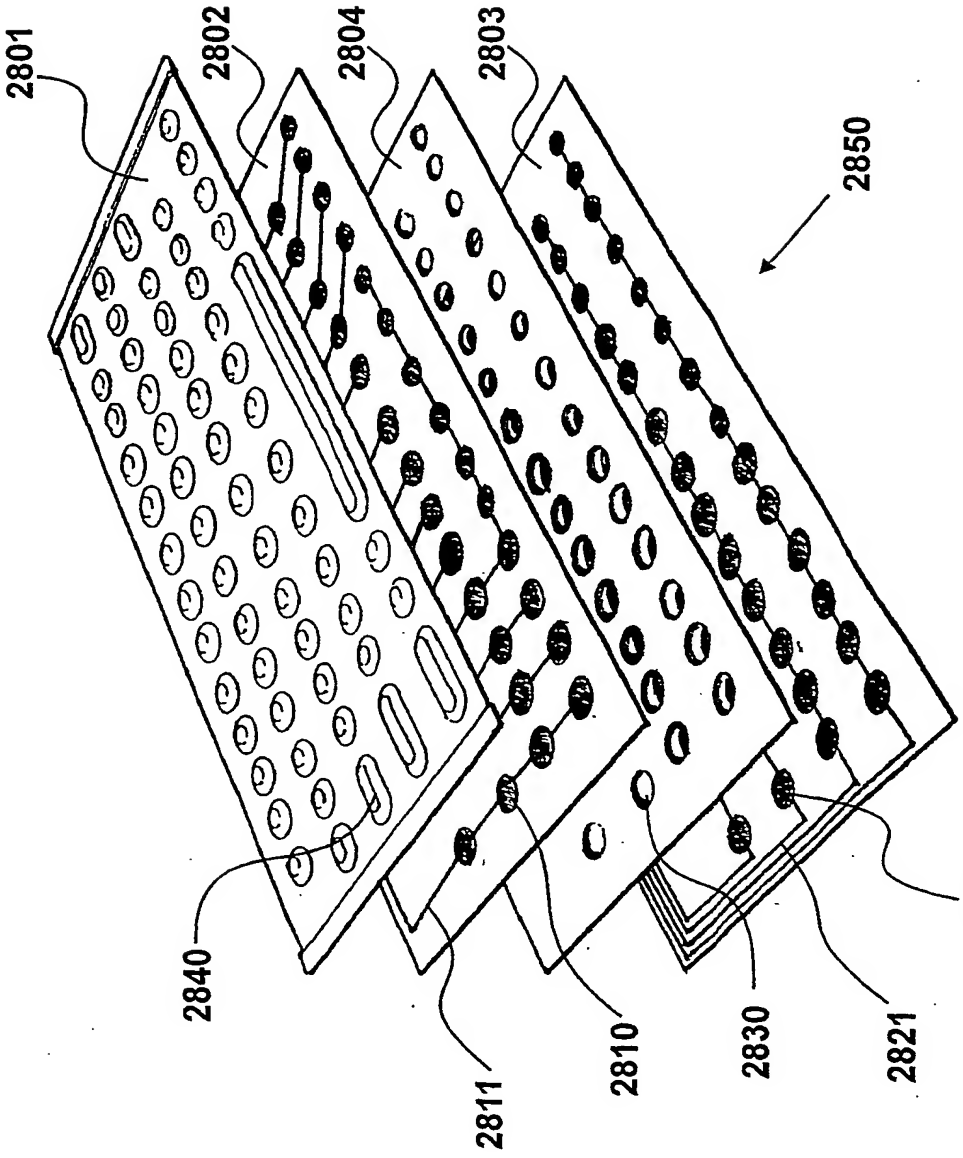

Figure 28

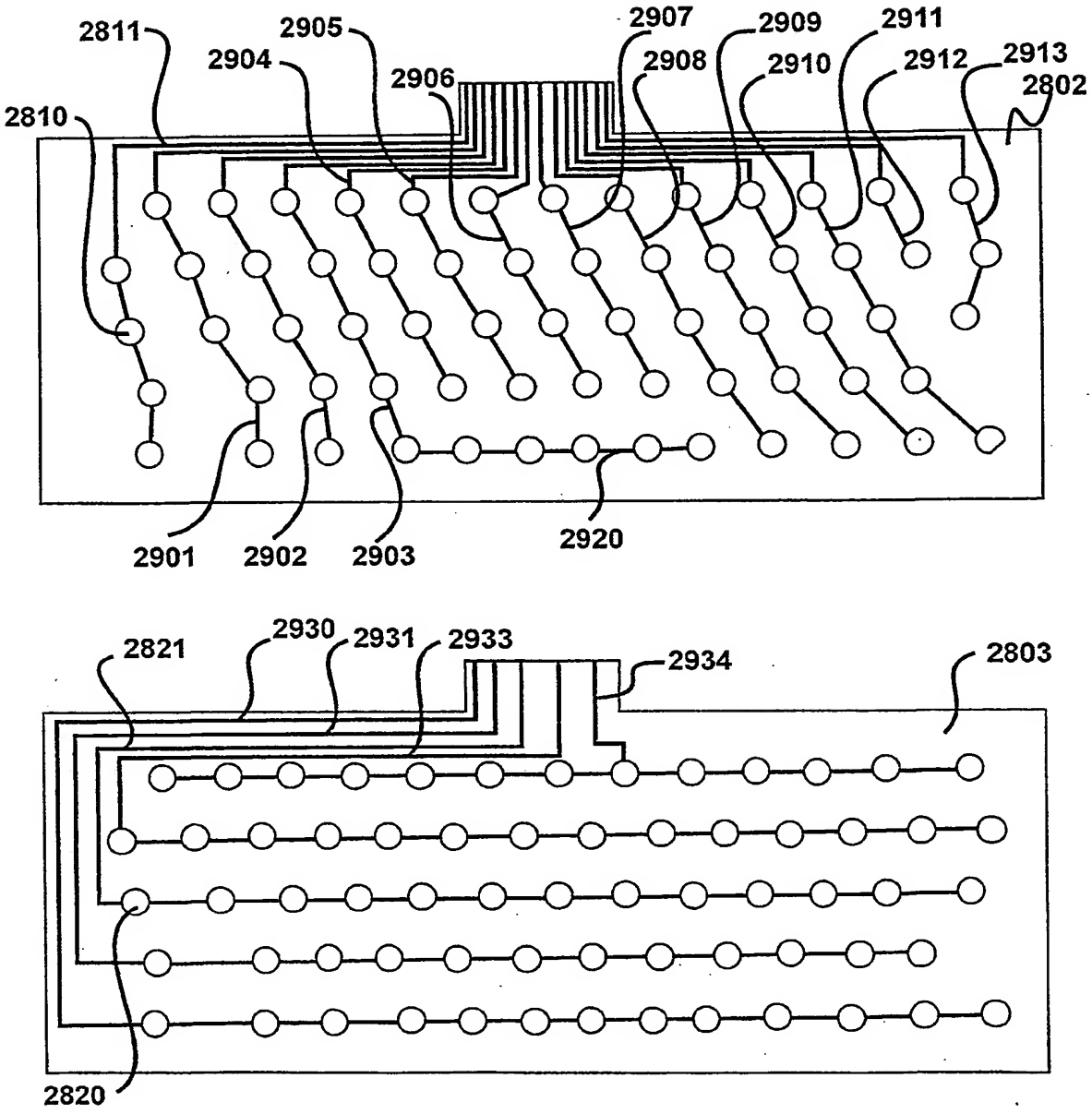
2811
2905
2907
2909
2911
2904
2908
2910
2912
2913
2906
2802
2810
2901
2902
2903
2920
2821
2930
2931
2933
2934
2803
2820

Figure 29

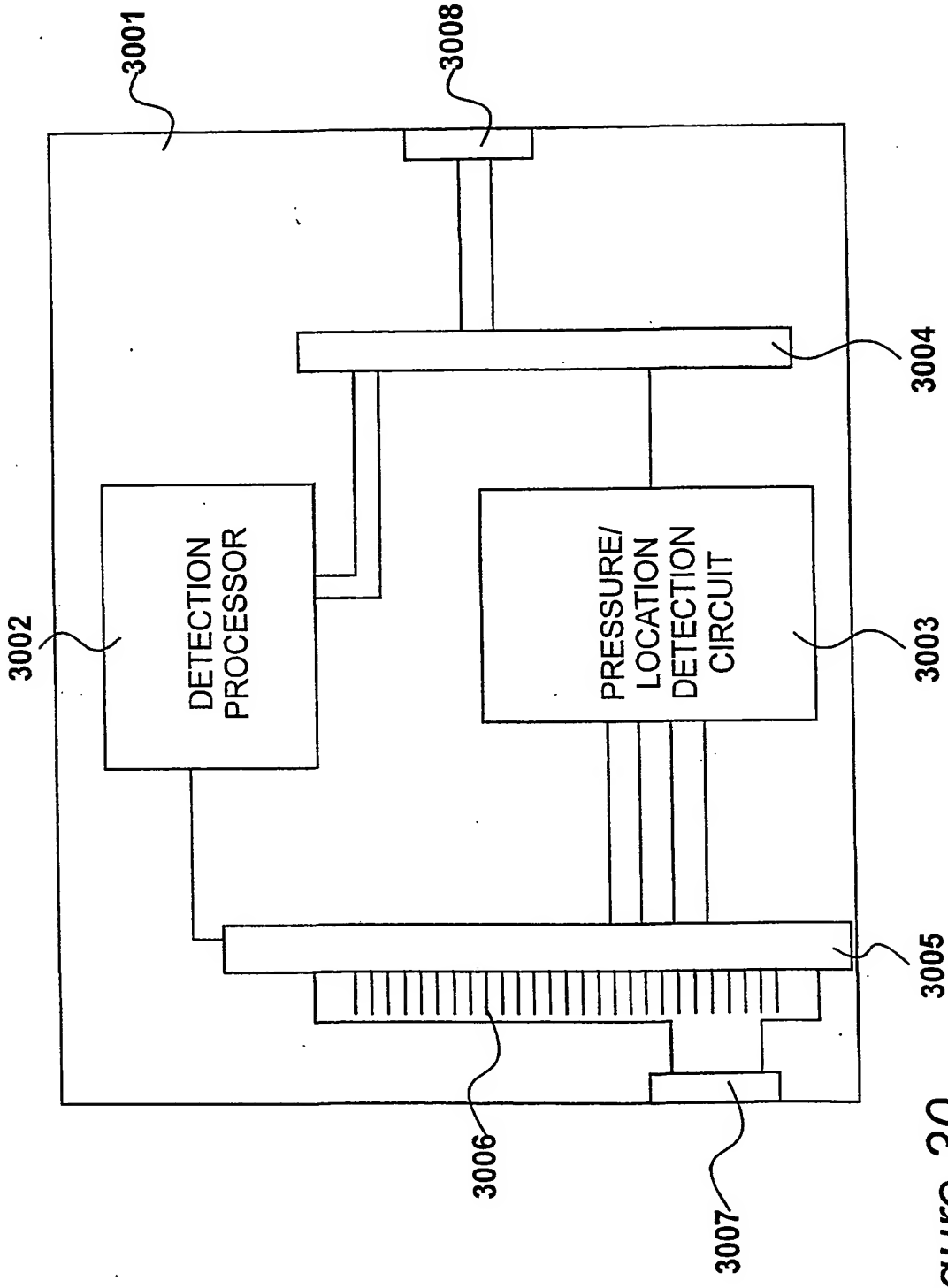
3001
3008
3004
DETECTION PROCESSOR
3002
PRESSURE/ LOCATION DETECTION CIRCUIT
3003
3005
3006
3007

Figure 30

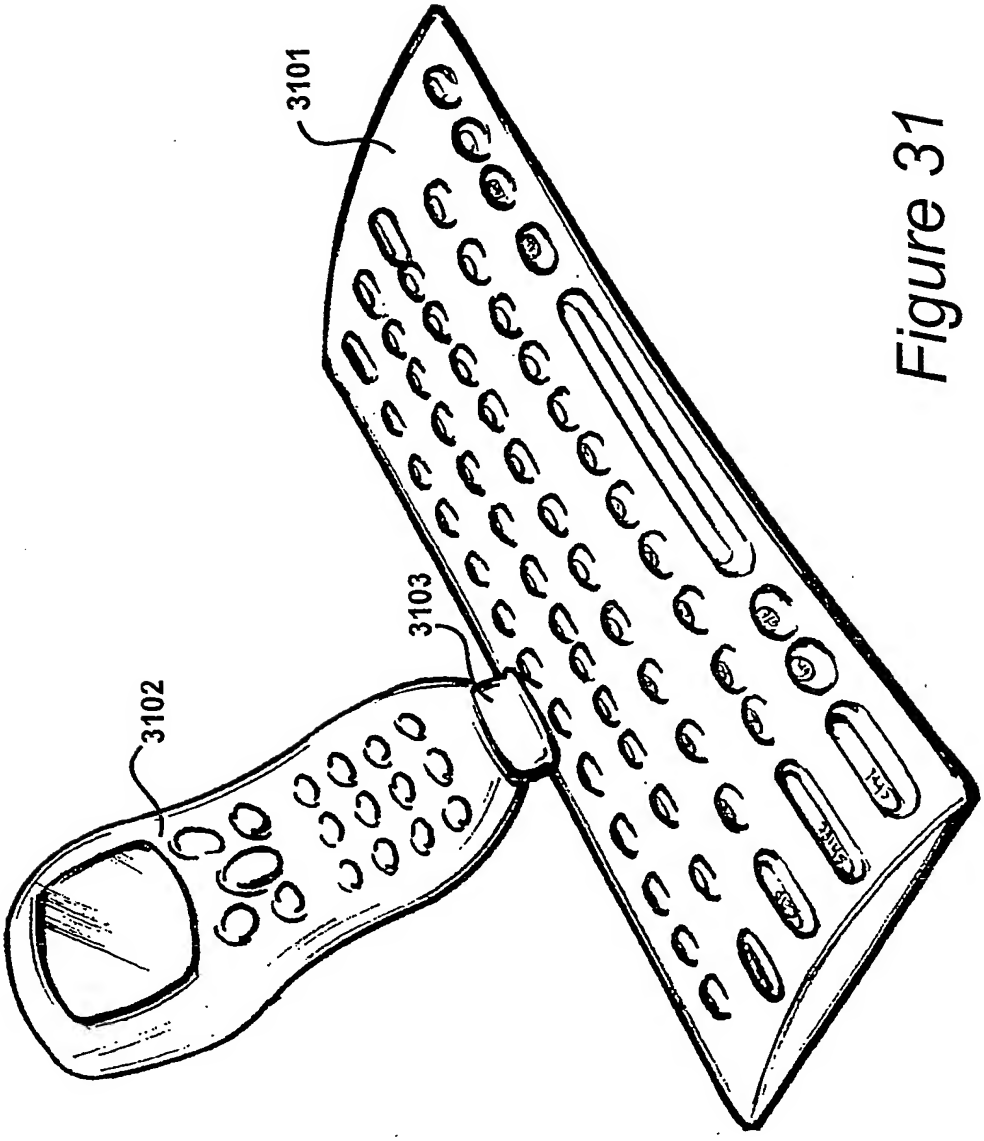

Figure 31

Figure 32

INTERNATIONAL SEARCH REPORT

national Application No
PCT/GB 01/02234

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06F3/02 G06F1/16 H01H13/70 H05K3/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06F H01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, IBM-TDB, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 295 12 756 U (GOECKEL KARL) 12 October 1995 (1995-10-12) page 2, paragraph 2 page 4, paragraph 2 -page 6 page 8, paragraph 2 -page 11, paragraph 1	1,2,5-8, 11-13, 27-29
A	---	18
X	WO 00 10878 A (TREKWARE CORP ;WEISHAAR THOMAS (US)) 2 March 2000 (2000-03-02) page 14, line 19 - line 23 page 4, line 19 -page 5, line 17	1,3,4,8, 27-29

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 November 2001	08/11/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bailas, A

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INTERNATIONAL SEARCH REPORT

Information on patent family members

national Application No
PCT/GB 01/02234

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 29512756 U	12-10-1995	DE 29512756 U1	12-10-1995
WO 0010878 A	02-03-2000	AU 5565799 A	14-03-2000
		WO 0010878 A2	02-03-2000

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